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ABSTRACT

The purpose of this project was to develop a prototype expert instructional design system (ID Expert) which would demonstrate the feasibility of a consultation system for use by inexperienced instructional designers. The prototype gathers information from the designer and then makes recommendations for instructional design decisions. The output of the consultation is an instructional design specification which identifies each of the modules needed, the instructional objectives associated with each module, the instructional functions of each module, and the instructional transactions necessary to accomplish each function. This design specification provides the skeleton from which materials can be developed. The domain of the prototype system is limited to goals involving concept classification with a "kinds" taxonomy content structure and goals involving procedures for device operation with a "path algorithm" content structure. The system has been implemented using the S.1 expert system shell (Teknowledge Inc.) and runs on a VAX computer. The knowledge base includes in excess of 400 rules. The report describes: (1) the project's purpose, audience, scope, and environment; (2) the conceptual design; and (3) the implementation design, including a "top level" view of the system's structure, detailed descriptions of system components and knowledge representation, and a description of the user interface and consultation process. (GL)

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DESIGN DOCUMENT & TECHNICAL REPORT

IMPLEMENTATION OF AN EXPERT SYSTEM FOR INSTRUCTIONAL DESIGN: PHASE 2

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IMPLEMENTATION OF AN EXPERT SYSTEM FOR INSTRUCTIONAL DESIGN: PHASE 2

TABLE OF CONTENTS

1. INTRODUCTION 2
- 1.1. Purpose of the project 2
- 1.2. Audience 3
- 1.3. Scope 3
- 1.4. Environment 4

2. CONCEPTUAL DESIGN 6
- 2.1. Components of an Instructional System 6
- 2.2. DOMAIN 8
  - 2.2.1. Types of Content Structures 9
  - 2.2.2. Compound Content Structures (elaboration) 12
  - 2.2.3. Complex Content Structures (nesting) 14
  - 2.2.4. Content Structures included in prototype 14

3.0 IMPLEMENTION DESIGN 17
- 3.1 "TOP LEVEL" VIEW OF SYSTEM STRUCTURE 17
- 3.2 DETAILED DESCRIPTION OF SYSTEM COMPONENTS 18
  - 3.2.1 GOAL DECISION (SELECT A GOAL) 18
  - 3.2.2 CONTENT STRUCTURE DECISION 25
  - 3.2.3 KINDS CONSULTATION 31
    - 3.2.3.1 Content Structure Elaboration and Instantiation 31
    - 3.2.3.2 Recommended Course Organization 35
    - 3.2.3.3 Recommend Module Functions 37
    - 3.2.3.4 Recommended Transaction Decisions 38
    - 3.2.3.5 Recommend Transaction Characteristics 43
  - 3.2.4 PATHS CONSULTATION 45
    - 3.2.4.1 Content Structure Elaboration and Instantiation 45
    - 3.2.4.2 Recommended Course Organization 45
    - 3.2.4.3 Recommended Strategy 46
    - 3.2.4.4 Recommended Transactions 54
- 3.3 DESCRIPTION OF KNOWLEDGE REPRESENTATION -RULES 60
  - 3.3.1 GOAL/CONTENT STRUCTURE DECISION RULES 61
  - 3.3.2 MOTIVATION EXPERT (see section 3.2.1.1) 65
  - 3.3.2 KINDS CONSULTATION 68
    - 3.3.2.1 Course Organization Rules 68
    - 3.3.2.2 Module Sequence Algorithm 73
    - 3.3.2.3 Module Function Rules 75
    - 3.3.2.4 Transaction Type Rules 75
    - 3.3.2.5 Transaction Characteristic Rules 77
  - 3.3.3 PATHS CONSULTATION 83
    - 3.3.3.1 Course Organization Rules 83
    - 3.3.3.2 Strategy/Transaction Rules 84
- 3.4 USER INTERFACE -- CONSULTATION PROCESS 86
  - 3.4.1 KINDS CONSULTATION 86
  - 3.4.2 PATH CONSULTATION 94

LIST OF FIGURES

Figure 2.1 Illustration - Components of an Instructional System 6
Figure 2.2 Illustration of PARTS Taxonomy 9
Figure 2.3 Illustration of KINDS Taxonomy 10
Figure 2.4 Illustration of PATH algorithm 11
Figure 2.5 Illustration DECISION algorithm 11
Figure 2.6 Illustration of Elaborated PARTS taxonomy 13
Figure 2.7 Illustration of Elaborated KINDS taxonomy 13
Figure 2.8 Illustration of Elaborated PATH algorithm 13
Figure 2.9 Illustration of Elaborated DECISION algorithm 14
Figure 2.10 Illustration - Kinds of Pumps 15
Figure 2.11 Illustration - Operating Spreadsheet 16
Figure 3.1 KINDS: PARTS Content Structure 26
Figure 3.2 PATH: PARTS Content Structure 26
Figure 3.3 CONDITIONS/PATHS: PARTS Content Structure 27
Figure 3.4 PATH: PARTS x KINDS Content Structure 28
Figure 3.5 KINDS/PATHS: PARTS Content Structure 29
Figure 3.6 CONDITIONS/PATHS: PARTS x KINDS Content Structure 30
Figure 3.7 KINDS/CONDITIONS/PATHS: PARTS Content Structure 31
Figure 3.8 Single-Node Module 36
Figure 3.9 Coordinate-set Module 36
Figure 3.10 Coord-SuperOrd Module 36
Figure 3.11 SuperOrd-Node Module 36
Figure 3.12 An example of an Explore Synthesis transaction 38
Figure 3.13 An Explore Synthesis transaction showing an example 39
Figure 3.14 Tutorial transaction showing the definition and an example 39
Figure 3.15 Compare Contrast Transaction showing attribute table 40
Figure 3.16 Compare Contrast transaction with an example and attribute table 41
Figure 3.17 Compare Contrast transaction showing a comparison example. 41
Figure 3.18 Compare Contrast transaction showing two attribute tables. 42
Figure 3.19 Compare Contrast showing contrasting examples. 42
Figure 3.20 Familiarity instruction 47
Figure 3.21 REM: LCBI Strategy 48
Figure 3.22 REM: SCBI Strategy 48
Figure 3.23 REM: LSCBI Strategy 48
Figure 3.24 LCBI -- Learner Control Basic Instruction 49
Figure 3.25 SLCBI -- Structured Learner Control Basic Instruction 50
Figure 3.26 SCBI -- System Control Basic Instruction 51
Figure 3.27 DC FAM Strategy 52
Figure 3.28 DC FAM/REM Strategy 52
Figure 3.29 Show Parts Transaction 54
Figure 3.30 Explore Parts Transaction 55
Figure 3.31 Name Parts Transaction 56
Figure 3.32 Demonstration Transaction 57
Figure 3.33 Execute Operation Transaction 58
Figure 3.34 Recognize Steps Transaction 59
Figure 3.35 Goal/Content Structure decision tree for "what" orientation 62
Figure 3.36 Goal/Content Structure decision tree for "how" orientation" 63
Figure 3.37 Goal/Content Structure decision tree for "works" orientation. 64
Figure 3.38 Motivation Expert Decision Tree part 1 66
Figure 3.39 Motivation Expert Decision Tree part 2 67
Figure 3.40 Course Organization for Path Module 83
Figure 3.41 Decision Rules for Strategy/Transaction for Path 85

LIST OF TABLES

Table 3.1 Module Type 68
Table 3.2 Sequence Pseudo Code Algorithm 74
Table 3.3 Module Function 75
Table 3.4 Transaction Type 76
Table 3.5 Transaction Sequence 78
Table 3.6 Transaction Content Representation 80
Table 3.7 Transaction Presentation 81
Table 3.8 Transaction Control 82
Table 3.9 Path Sequence Algorithm 83

IMPLEMENTATION OF AN EXPERT SYSTEM FOR INSTRUCTIONAL DESIGN: PHASE 2

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SUMMARY

The purpose of this project was to develop a prototype expert instructional design system which would demonstrate the feasibility of a consultation system which could be used by inexperienced instructional designers to assist in instructional design decision making. Unlike most so called authoring systems this prototype is a consultation system to guide the instructional design process prior to the programing stage rather than assisting with the programing (implementation) activities.

The prototype gathers information from the user/designer and then makes recommendations for each of the following instructional design decisions:

What is the orienting goal of the instruction?
What is the content structure which best corresponds to this goal?
Guidance for elaborating and instantiating this content structure.
What modules are necessary for teaching the content?
What instructional transactions are best for each of these modules?
What are some of the attributes of each of these transactions?

The output of the consultation is an instructional design specification which identifies each of the modules needed, the instructional objectives associated with each module, the instructional function(s) of each module, the instructional transaction(s) necessary to accomplish each function. This design specification provides the skeleton from which instructional materials can be developed. Future versions of the system will link the instructional design expert to authoring (implementation) capabilities.

The domain of the prototype system is limited to goals involving concept classification with a KINDS TAXONOMY content structure and goals involving procedures for device operation with a PATH ALGORITHM content structure. Other domain areas have been identified and future implementations of the system will include these areas to make the system a comprehensive consultation system appropriate for most instructional design situations.

The prototype has been implemented using the S.1 expert system shell (Teknowledge Inc.) and runs on a VAX computer. The knowledge base includes in excess of 400 rules. The next phase of the system will port the expert system to a desk top platform with improved user interface.

The prototype explored a number of different reasoning procedures including rules based on decision trees and rules based on the accumulation of evidence using certainty factors. Unlike many expert systems which are directed toward a single decision this prototype makes recommendations on a series of decisions and allows the user/designer to confirm each recommendation as the reasoning proceeds. The prototype explored allowing the user/designer to back up and provide different information if a recommendation was not acceptable. The prototype explored the use of nested miniexperts for information where the user/designer may need more assistance. The prototype uses a mixed approach in which declarative (rule based) programing is combined with procedural programing which controls the reasoning and information gathering process.

IMPLEMENTATION OF AN EXPERT SYSTEM FOR INSTRUCTIONAL DESIGN: PHASE 2

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1. INTRODUCTION

1.1. Purpose of the project

Several important instructional design and development needs led to the development of the ID Expert. These include: the lack of sufficient numbers of experienced instructional designers; the need for tools to make the instructional design process more adequate while at the same time making it more efficient; the need for more adequate instructional design models in intelligent tutoring systems; and the need for more precision in the specification of instructional design theory.

Guidance for inexperienced instructional designers. It is not uncommon in many training environments for a professional to find himself or herself assigned to the preparation of training materials with only a minimum amount of formal training in instructional design, learning or related disciplines. Often the only recourse for these "assigned" instructional designers it to rely on their own training experience for guidance thus perpetuating inadequate practices or preserving the status quo. These inadequately trained instructional designers often are unable to adequately consider more appropriate learning principles and more effective instructional techniques in the training materials they must prepare. The primary purpose of the ID Expert is to capture some of the best instructional design and learning expertize available in a form that can serve as an expert consultant to these naive instructional designers thus enabling them to be more adequately guided in their instructional design efforts.

Tools for making instructional design more efficient. The hardware for new high technology instructional delivery systems is relatively inexpensive and available for wide spread adoption. Often these systems have been demonstrated to enable far more imaginative instruction than is possible with previously available delivery systems. However, the cost of developing materials for such systems is extremely high and continues to increase thus slowing the adoption of these technologies. Attempts to build authoring languages and systems have for the most part attacked only one aspect of these development costs, i.e. the programing effort. However, most of the development cost is not in programing (often less than 25% of the total effort) but rather in instructional design. A second purpose of the ID Expert is to provide a design tool to facilitate the efficiency of this preprograming design effort. The ID Expert enables the designer to explore a wide variety of possible designs while simultaneously considering a wide range of contributing variables. The ID expert automates much of this decision making effort thus enabling the designer to much more rapidly formulate development specifications and to modify those specifications for different settings, student audiences and subject matter constraints.

Instructional models for intelligent tutoring systems. Significant progress has been made in developing advanced programing techniques that enable computer based instructional systems to demonstrate considerable intelligence. In the development of these advanced tools the instructional models involved have often been based on expediency or the previous educational experiences of the project

investigators rather than on a careful analysis of the learning and instruction literature. Many of the developers of these systems are now reaching out for information about instruction and learning that can be incorporated into these advanced computer based instructional tools. A secondary purpose of the ID Expert is to capture some of the best instructional design and learning expertize available in a form of production rules that can more easily be incorporated into other intelligent instructional systems.

More precise instructional design theory. Much of the available information on learning and instruction is very nonspecific often consisting of broad generalities requiring considerable interpretation in order to convert these general principles into a specification for a specific instructional product. Another purpose of the ID Expert was to translate broad general instructional design and learning principles into specific production rules sufficient to enable the computer to reason with these rules and recommend specifications for the development of a particular product. The ID Expert thus becomes a model for the future specification of instructional design theory in a form that is more precise and thus more useful in prescribing educational practice.

1.2. Audience

The ID Expert is designed primarily for instructional designers who have had only minimal training in instruction, learning and related disciplines. Its purpose is to provide guidance in making instructional design decisions to the end that the products, developed using the instructional specification output from the ID Expert, will more adequately implement what is known about learning and instructional design.

A secondary audience for the ID Expert are experienced instructional designers. The ID Expert enables an experienced designer to play the "what if game" more efficiently by seeing how design specifications change when the parameters of the instructional situation are changed. The ID Expert considers a much wider variety of factors in making any given recommendation than is practical for designers to consider without such a tool. While the rules in the prototype are based on the best estimate of the instructional design domain expert used for the development of the system, the mechanism exists for the system to systematically consider data from a large number of experimental studies in making recommendations.

1.3. Scope

The ID Expert is limited to instructional design decisions commencing after some front end analysis has been completed. It assumes that a subject matter expert has been consulted or is present during the consultation and that the subject matter content to be taught has been selected (job analysis is completed) and sample materials gathered. The system will assist in the instructional analysis and organization of this subject matter content but will not assist in the selection of the material to be included in the course.

The output from the prototype ID Expert is a design specification for a course. This specification can then be used by an instructional developer to implement the design using an appropriate media delivery system. This specification includes recommendations for: (1) instructional modules including the content and objectives for these modules; (2) course organization and sequence including menus, pre and post integrative modules and instructional modules; (3) one or more transactions for

accomplishing each of the instructional functions for each module; and (4) detailed specifications for each of these transactions.

The specifications resulting from consultation with the ID Expert do not include the management information necessary for determining on-line advisor rules for assisting the student in the question of when to begin the next module or which module should be next. This information could be added to the system but is not included in the prototype.

The specifications do not include the management information necessary for determining on-line advisor rules for assisting the student in the question of when to begin the next transaction or which transaction should be next. This information could also be added to the system but is not included in the prototype.

The ID Expert makes no assumptions about media delivery system. It recommends transactions that are appropriate for teaching the objectives of the course without regard for how these objectives may be implemented. The descriptive material in this report often uses computer based instruction as a way to illustrate the transactions recommended but the recommendations are not limited to CAI or Interactive Video. The system could be expanded to assist with the media selection but the current implementation of the system does not include guidance for media selection.

The ID Expert does not include many of the detailed specifications necessary for preparing delivery in a given media. Specifications for such details as answer processing, error checking, screen design, program structure, data structures and programing are not included. Rules governing these detailed specifications could be added to the system but are not included in the present implementation.

The ID Expert is not an authoring system or language. In contains no screen editors, graphics editors, or other tools for preparing CIA or Interactive video learning materials.

Finally, the ID Expert is not yet a general purpose instructional design consultant. The current implementation is limited to two types of content structure and related instructional objectives. These are "kinds of taxonomies" (concepts) and "path procedures" (device operation procedures). While these two types of structure encompass a large body of instructional materials there are many other types of content structure which would require different modules, course organizations and transactions than those recommended by the present prototype. The system could be expanded to include these other instructional outcomes but recommending specifications for these other types of outcomes is beyond the scope of the present implementation.

1.4. Environment

1.4.1. Software.

The prototype Instructional Design Expert is implemented using the S.1 expert system shell marketed by Teknowledge Inc.

1.4.2. Hardware.

The S.1 expert system shell will run on a variety of systems. The prototype system was developed on a VAX implementation of S.1 at Utah State University.

2. CONCEPTUAL DESIGN

2.1. Components of an Instructional System

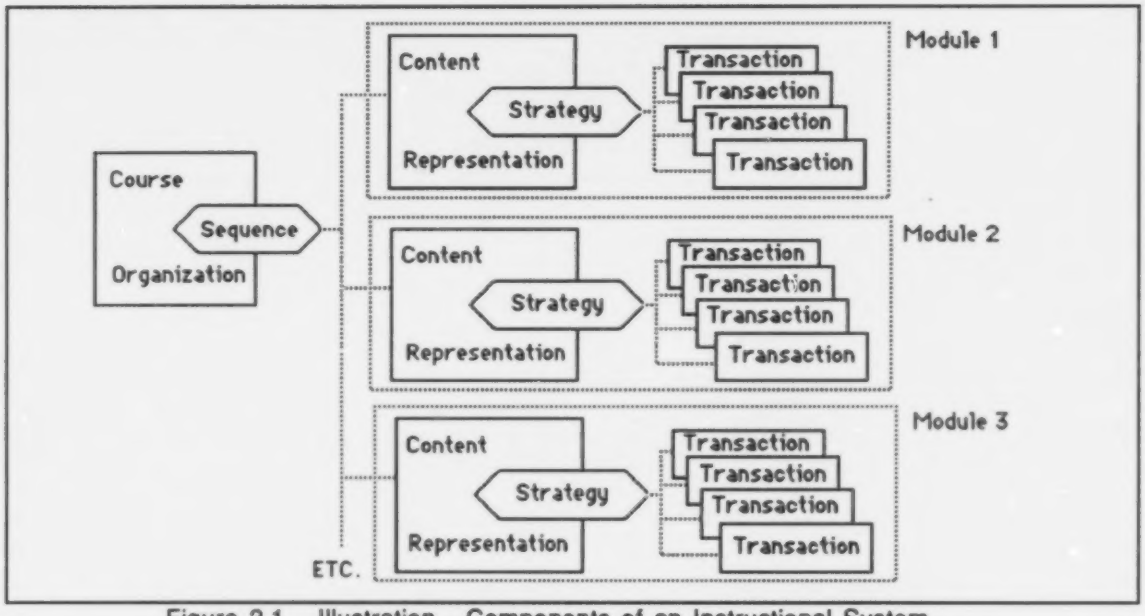


Figure 2.1 Illustration - Components of an Instructional System

Instructional systems can be conceptualized in many ways. To facilitate communication the following paragraphs identify and define the components of an instructional system for which the ID Expert provides design guidance. The figure identifies the following components of an instructional system:

(1) course organization
(2) sequence
(3) modules
(4) content representation
(5) transactions
(6) strategy

There are several design tasks facilitated by the ID Expert these are:

(1) to identify the modules to be included in the course including the instructional function , subject matter content, and objective(s) for each module;
(2) to sequence these modules in a course organization;
(3) to determine the transactions which best accomplishes each of the instructional functions for each module;
(4) to determine the content representation required for each transaction;
(5) to determine the sequence, control and mode of presentation within each transaction. The following paragraphs describe each of the components.

Content Structure. Content structure (not shown in the figure) is the organization of the subject matter content. A content structure diagram is often

included as part of the content representation. Different content structures are appropriate for different instructional goals. The ID Expert contains a taxonomy of different types of content structures and rules for determining which structure(s) are most appropriate for a given goal and audience characteristics. The ID Expert assists the designer in selecting an appropriate content structure(s) for the goals and student audience of the course. The ID Expert also guides the designer in instantiating this content structure, that is, the designer is guided in organizing the content previously selected for inclusion in the course. The instantiated content structure is the primary information used by the ID Expert to determine recommended modules, module content, module objectives and course organization.

Module. The module is the primary unit of course organization specified by the ID Expert. A module is a unit of instruction composed of standard components. The figure indicates that a module consists of three primary components:

(1) a set of transactions which enables the student to interact with the content representation;
(2) the content representation which is the actual material to be learned or with which the student interacts to learn about the content; and
(3) a set of strategy rules which determine the next transaction and when the student should shift to the next transaction.

Transaction. A transaction is "... a communicative action or activity involving two parties or two things reciprocally affecting or influencing each other . . ." (Webster). A transaction is a mutual, dynamic, real-time give-and-take between the instructional system and the student in which there is an exchange of information. Many tutorial instructional systems are described in terms of frames and questions, however, frames and questions enable only a limited number of transaction types. Adequate instruction, especially with experiential subject matter content representation, requires a wider range of student interaction. A transaction is a complete sequence of presentations and reactions necessary to accomplish some instructional function. A given instructional function can often be accomplished by two or more different types of transactions. The ID Expert includes a taxonomy of transactions appropriate for particular instructional functions, within particular content structures for accomplishing particular instructional goals. The ID Expert recommends appropriate transactions for each function within each module based on goal characteristics, audience characteristics, the content structure, and content characteristics.

Strategy. Strategy is a set of rules for determining which transaction should be next and when the student should shift to the next transaction. Strategy rules also indicate whether the learner or the system should make this decision. Recommending strategy rules is beyond the scope of the prototype system.

Content Representation. Content Representation (also called knowledge representation) is the content material (domain knowledge) with which the student interacts. There are two major categories of content representation: structural and experiential.

(1) Structural representations consist of domain knowledge which has been selected and isolated for presentation to the student. This information often consists of generalities, examples, prerequisite material, context, and background material that has been collected about a given domain. Structural knowledge is similar to more

familiar "text book" representations but may include graphic materials such as animations, video, and nonexperiential simulations.

(2) Experiential representations consist of domain knowledge which simulate devices, events or processes in a way which enables the student to interact directly with these materials. Experiential representations respond to student input in ways similar to the response of the actual device, event or process simulated. The ID Expert recommends the content representation(s) necessary to implement the recommended transactions.

Course Organization. The course organization is the network of modules and the possible paths that the student may take in traversing this network. Course organization identifies pre and post integrative modules, menus, instructional modules and paths connecting these organizational components. The ID Expert recommends content organization based on goal characteristics, audience characteristics and the content structure.

Sequence. Sequence is a set of rules for determining which module should be next and when the student should shift to the next module. Sequence rules also indicate whether the learner or the system should make this decision. Sequence rules are beyond the scope of the prototype.

2.2. DOMAIN

The current implementation of the ID Expert provides guidance in preparing specifications for teaching concepts and device operation procedures. An underlying premise of the instructional design theory involved in the ID Expert is that a primary determinate of appropriate course organization, content representation and transactions is content structure. Content structure is the organization of a knowledge domain showing the content components and their relationship to one another. Instantiating a content structure is a form of knowledge acquisition in which appropriate domain knowledge is acquired from the domain (subject matter) expert and organized in a way appropriate for a given goal, goal characteristics and student characteristics. A completely instantiated content structure would encompass all of the knowledge (content) representations necessary to implement an instructional system to teach this domain.

A fundamental premise of the instructional design theory underlying the ID Expert is that there are different kinds of instructional outcomes (Gagne, 1984) and that different types of content structures are appropriate for representing the knowledge necessary to the acquisition of a particular kind of outcome. Furthermore, the instantiation of a given type of content structure provides most of the information necessary to make appropriate recommendations for modules, the content of each module, the function(s) of each module, the objective(s) for each module, the course organization, the type of transactions within each module, and the content representation(s) required for each type of transaction. Therefore the ID Expert assists the designer to select the appropriate type of content structure for the goal, goal characteristics and audience characteristics of the course and guides the instantiation of this content structure.

The current implementation of the ID Expert deals primarily with two kinds of content structure: a "KINDS of taxonomy" and a "PATH algorithm". (See explanation below). Some complex content structures (see section on complex content

structures) are also recommended as required by certain goals. Future implementations of the ID Expert will be expanded to include other types of content structures thus enabling the system to recommend specifications for a wider range of instructional outcomes.

2.2.1. Types of Content Structures

List. Lists are the most primitive form of content structure. An unordered list is really no structure. Lists can be ordered providing the most basic form of content structure. A list can be ordered on any dimension or attribute of the items in the list.

The next level of organization for a list is to cluster the items in a list forming the most primitive form of taxonomy. A PARTS taxonomy is an example of a clustered list where the subordinate nodes are parts of the superordinate node.

A list may be most appropriate for teaching specific facts or information. A list may be appropriate if the goal requires the student to:

. . . remember specific events, dates, persons, places or sources.
. . . remember a set of symbols.

Taxonomy. A taxonomy is an organization which organizes subordinate items under superordinate items. Taxonomies are usually represented by tree diagrams. The nature of the subordination determines different kinds of taxonomic structures.

Items in a list are more easily learned if they are clustered in groups of items where the number of items in each group is within the short term memory limits of the learner (The magic number seven plus or minus two). A PARTS taxonomy is an example of such a taxonomic clustering where the subordinate nodes are parts of the item identified by the superordinate node. A PARTS taxonomy is a content structure associated with remembering facts, parts of a device, etc.

A PARTS taxonomy is appropriate if the goal requires the student to:

. . . identify or name the parts and/or functions of a device or object.

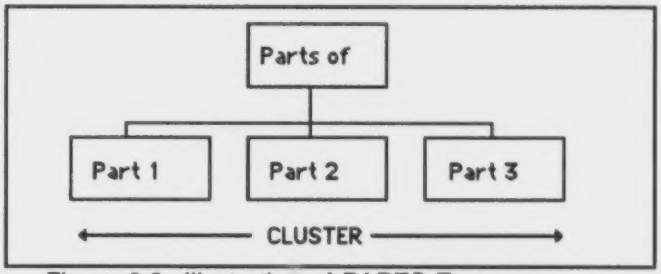


Figure 2.2 Illustration of PARTS Taxonomy

A KINDS taxonomy is also represented by a tree diagram where subordinate nodes represent kinds of the item represented by the superordinate node. A KINDS taxonomy is fundamental for identifying concepts. A KINDS taxonomy is appropriate if the goal requires the student to:

. . . discriminate two or more different kinds of objects, events or symbols from one another.
. . . sort objects, events or symbols into categories.
. . . identify different objects, events or symbols as instances of a more general category.
. . . order a series of objects, events or symbols relative to some dimension.

Other forms of taxonomy structure include PROPERTIES or FUNCTIONS taxonomies where the subordinate nodes are respectively properties or functions of the superordinate node.

A PROPERTIES taxonomy is most appropriate for teaching associated information about an object or process. A properties taxonomy is appropriate if the goal requires the student to:

. . . describe the characteristics of an object or process.
. . . identify a characteristic as a property of a particular object or event.

A FUNCTIONS or CONDITIONS taxonomy is most appropriate for teaching a set of related procedures each of which are necessary to accomplish some purpose when the execution does not follow a particular path. A functions taxonomy is most appropriate if the goal requires the student to:

. . . select and/or execute (do) an appropriate action from a set of alternative actions.

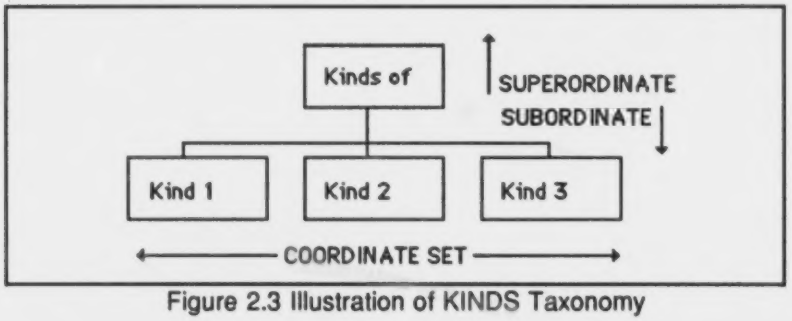


Figure 2.3 Illustration of KINDS Taxonomy

Path Algorithm. A path algorithm is usually represented by a flow chart which indicates steps and sequence for a series of actions or activities. Path algorithms are appropriate when the orientation is HOW to do something and the learner must acquire a procedure. A path algorithm is appropriate if the goal requires the student to:
. . . operate a specific device or any of several similar devices.
. . . assemble or disassemble a specific device or any of several similar devices.

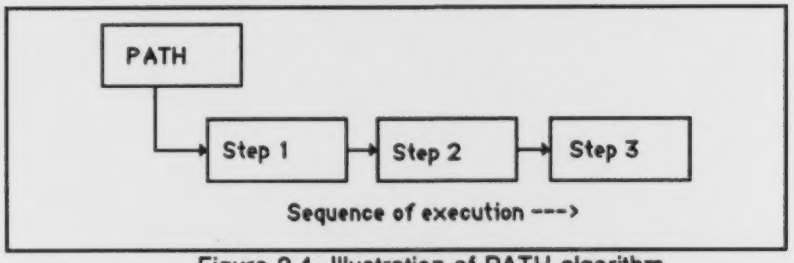


Figure 2.4 Illustration of PATH algorithm

Decision Algorithm. A DECISION algorithm can also be represented by a flow chart or by a decision tree. Each branch represents a choice by the learner. Following a series of choices leads to a decision or conclusion. Whenever the student must select between two or more alternatives, such as choosing a function, classifying an instance of a concept, selecting an appropriate rule to apply, etc. a decision algorithm is implied. Decision algorithms are usually combined with other content structures to form complex structures such as concept classification) or selecting from two or more functions and executing the procedure associated with the function.

A decision algorithm is appropriate if the goal requires the student to:

. . . decide between two or more alternatives or options.

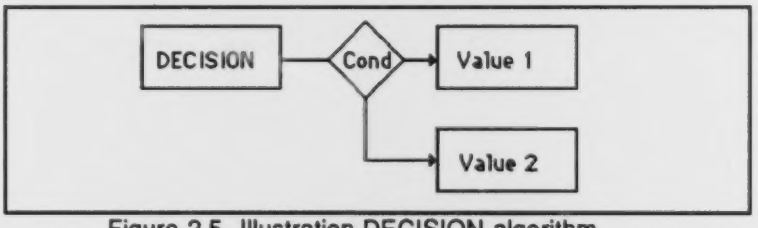


Figure 2.5 Illustration DECISION algorithm

Causal nets. Casual nets are usually represented by "and/or" graphs and represent WHY something operates as it does. Causal nets are beyond the scope of the prototype system and are not illustrated or explained in this Design Document and Technical Report nor are they recommended by the prototype system. Future expansions of the ID Expert will include causal net content structures.

A causal chain is most appropriate for teaching natural principles and processes. A causal chain is most appropriate if the goal requires the student to:

. . . predict the outcome for an event or series of events.
. . . derive or formulate a rule or principle.
. . . design or develop a product or communication.

An event chain is most appropriate for teaching cycles in nature and other sequential processes. An event chain is most appropriate if the goal requires the student to:

. . . describe a sequence of actions or activities.
. . . predict the outcome for an event or series of events.

2.2.2. Compound Content Structures (elaboration)

The previous paragraphs have identified some of the basic forms of content structure. In real world subject matter these simple forms must be expanded to accommodate the details of the knowledge to be taught. The fundamental principle underlying the elaboration of content structure is the limitation on short term memory. In order to be remembered and learned efficiently content must be organized to limit the number of items under consideration at any moment to approximately 7 ± 2. This clustering of information enables the student to handle great complexity by "chunking" the information so that there is only a limited amount of information in short term memory at any one time.

A PARTS taxonomy is elaborated by identifying parts, subparts, subparts of subparts, etc. The rule is that at a single level of a branch in the tree their are never more than 7 items. If the content requires more items then an intermediate clustering should be created to enable the magic number 7 rule to prevail.

A KINDS taxonomy is elaborated in a similar way. Kinds are identified, then kinds of kinds, etc. Again at any level of any branch the number of coordinate items should not exceed 7.

A PATH algorithm is elaborated by identifying substeps of steps, and substeps of substeps, for as many levels of complexity as are necessary consistent with the 7± 2 rule.

PATH algorithms can also be elaborated by including loops and branches in the path. The ID Expert does not yet accommodate this type of elaboration but future versions of the system will. Control steps include classic procedural functions such as IF THEN ELSE, WHILE TRUE DO, REPEAT UNTIL TRUE, FOR N TIMES REPEAT. Each of these conditional structures imply a decision function and hence elaboration which leads to branching which may require a complex content structure where a decision algorithm is nested within a path algorithm.

DECISION algorithms are elaborated by as many decision steps as may be necessary to accommodate the decision process being taught. Decision algorithms are usually combined with other content structures forming complex content structures.

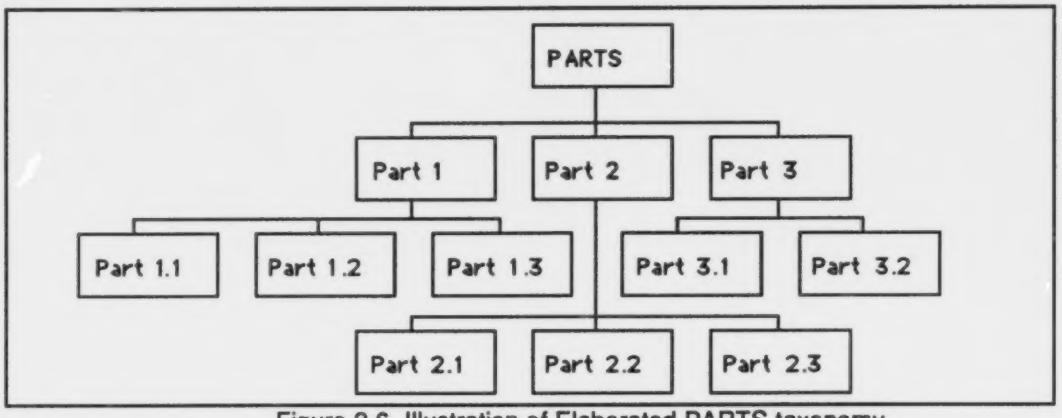


Figure 2.6 Illustration of Elaborated PARTS taxonomy

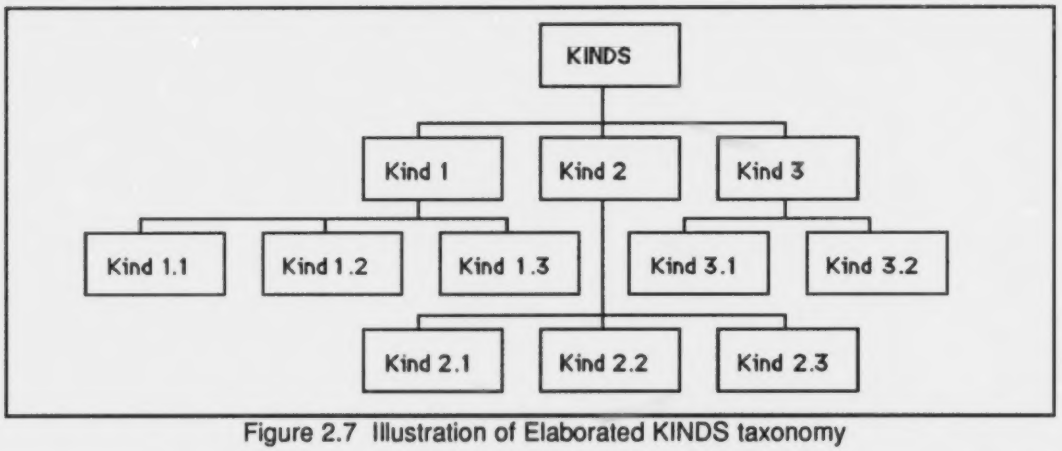


Figure 2.7 Illustration of Elaborated KINDS taxonomy

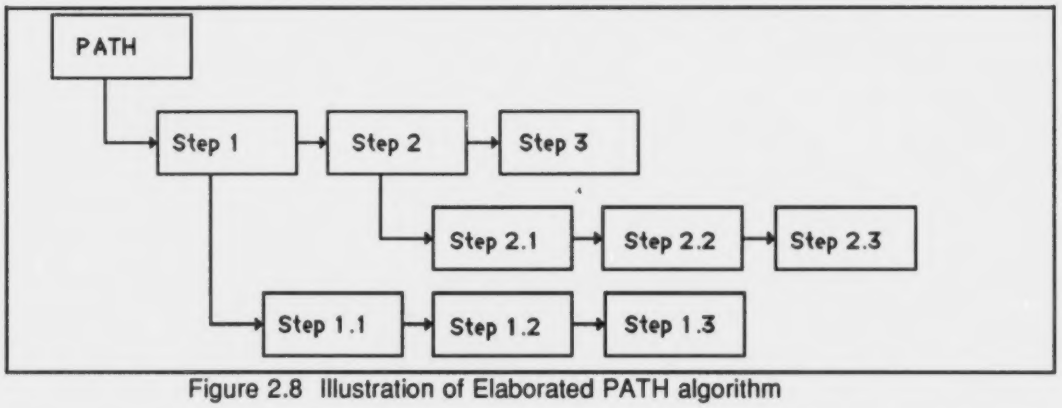


Figure 2.8 Illustration of Elaborated PATH algorithm

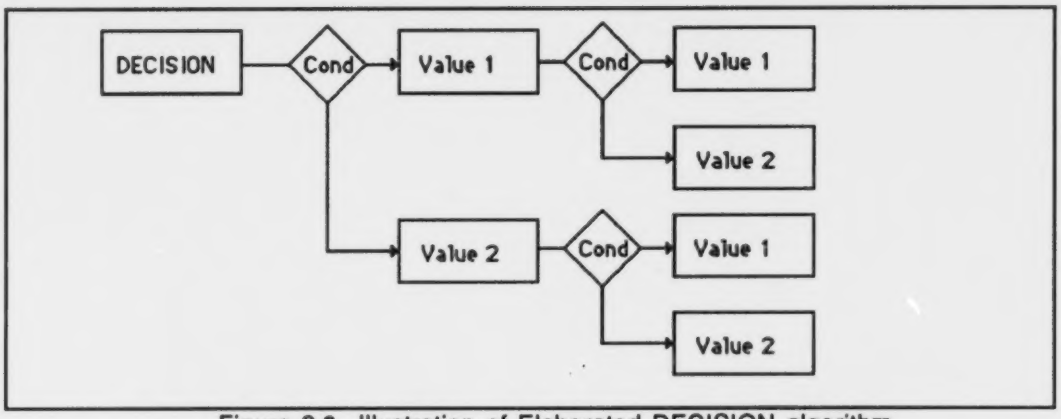


Figure 2.9 Illustration of Elaborated DECISION algorithm

2.2.3. Complex Content Structures (nesting)

Most objectives involve more than a simple content structure or even a compound (elaborated) content structure. For most instructional situations two or more simple content structures are combined to form a complex structure. We speak of one simple content structure being nested within another.

The PATH consultation of the ID Expert concludes with recommendations for content structures which are all complex in that they combine two or more simple content structures. Some of the combinations included include a PATH algorithm with a PARTS taxonomy as a prerequisite; a CONDITIONS taxonomy (a form of a KINDS taxonomy) combined with a PATH algorithm for each condition with a PARTS taxonomy as a prerequisite. A KINDS taxonomy combined with a CONDITIONS taxonomy each associated with a PATH algorithm and a series of PARTS taxonomies.

One of the contributions of the ID Expert is the identification of the rules which determine which combination of simple content structures is associated with a given learning outcome and set of learning conditions. Whereas there are only a few basic content structures there can be many different complex content structures.

2.2.4. Content Structures included in prototype

Kinds Taxonomy. A kinds of taxonomy is most appropriate for teaching concepts or goals involving classification or decision making. A kinds of taxonomy is appropriate if the goal requires the student to:

. . . discriminate between different kinds of symbols, objects or events.
. . . sort objects, events or symbols into categories.
. . . order a series of events, symbols or objects on some continuum.
. . . identify different objects, events or symbols as part of a more general category.

A kinds of taxonomy is usually represented by a tree diagram consisting of a superordinate node under which are a set of subordinate nodes. The subordinate nodes under a given superordinate node are called a coordinate set. The connecting lines stand for the phrase "kind of" and the diagram is interpreted by indicating that a given

subordinate node is a "kind of" its superordinate node. Figure 2. 3 illustrates these relationships.

The following example illustrates an incomplete "kinds of " taxonomy. The superordinate node is Pumps. The subordinate nodes of pump are piston pump, centrifugal pump and jet pump. The concepts piston pump, centrifugal pump and jet pump form a coordinate set of concepts. A piston pump is a "kind of" pump. A centrifugal pump is a "kind of" pump, etc. The diagram is expanded to show a second level of concepts, ie kinds of piston pumps. The subordinate nodes of piston pumps are piston pump, vane pump, lift pump, and diaphragm pump. The concepts piston pump, vane pump, lift pump and diaphragm pump form a coordinate set of concepts. A given "kinds of" taxonomy can be elaborated to have many levels of coordinate concept sets.

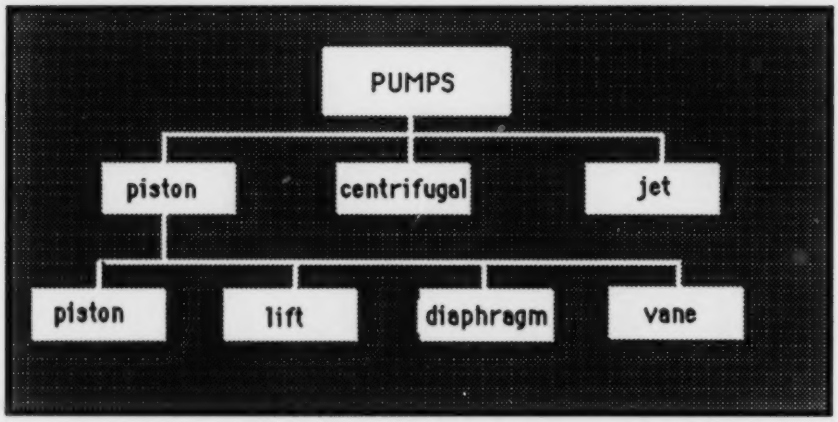


Figure 2.10 Illustration - Kinds of Pumps

Path Algorithm. A path algorithm is most appropriate for teaching procedure goals involving the execution of a series of steps. In the ID EXPERT prototype path algorithms have been identified for goals involving the operation or assembly of devices as follows:

. . . operate a specific device.
. . . operate any of several similar devices or pieces of equipment.
. . . assemble or disassemble a specific device.
. . . assemble or disassemble any of several similar devices or pieces of equipment.

A path algorithm is usually represented by a flow chart where each box indicates a step to be executed. A step consists of the following components: identification of the object, an action related to the object, a result of the action, and a consequence of the action.

A result is the change in the object that results from the action (e.g. a switch changes position). A consequence is some event or activity caused by the action (e.g. a motor starts). The lines between boxes represent the sequence of execution.

The example shows an incomplete analysis for the operation of a spread sheet. The content structure shown involves a complex content structure involving parts of the spreadsheet and a path algorithm.

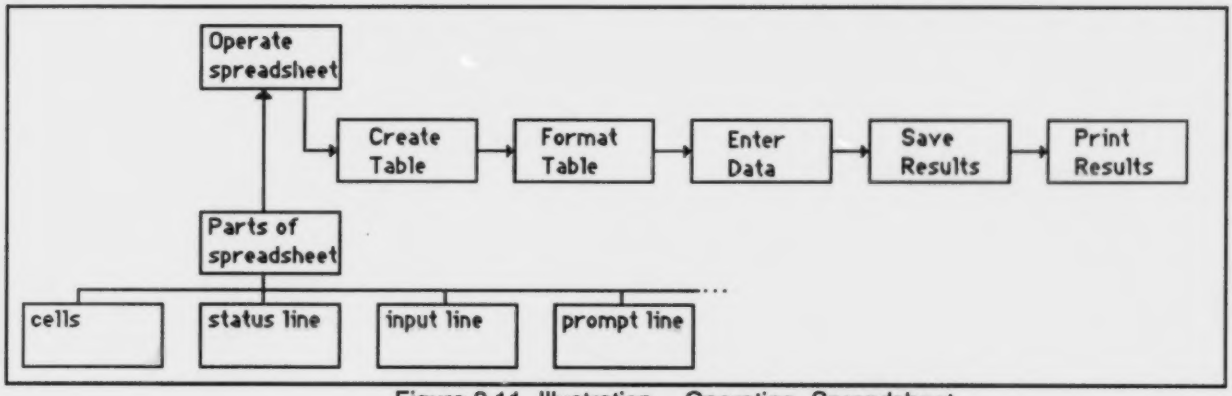


Figure 2.11 Illustration - Operating Spreadsheet

3.0 IMPLEMENTION DESIGN

3.1 "TOP LEVEL" VIEW OF SYSTEM STRUCTURE

ID EXPERT is a consultation system which gathers necessary information from the user/designer and then makes instructional design recommendations to the user. The following outline provides a summary of this consultation process. QUERY means to ask the user/designer a series of questions concerning the audience and the goal of the instruction. RECOMMEND implies that the system uses the information provided to do some reasoning and then makes a recommendation to the user/designer as a result of this reasoning. INSTANTIATE/ELABORATE is a knowledge acquisition function which gathers information specific to the user/designers instructional task in order to make recommendations specific to this content material.

The prototype has three distinct parts: the goal consultation, the kinds consultation and the path consultation. As a result of the goal consultation the system recommends a goal and content structure to the user. The system then assists the user to instantiate and elaborate the recommended content structure in terms of the specific content to be taught. The prototype can reason about only two types of content structure: the kinds and path content structures. A section of the prototype is dedicated to each of these paths. The nature of the rules and the approach to reasoning differs for the two branches. The kinds consultation is more general and uses an "accumulation of evidence" approach to reasoning. The path consultation is more specific and uses a "decision tree" approach to reasoning. Subsequent revisions of the system will make these two parts more consistent with one another. The nature of the two types of rules are explained in a later section of this Design Document and Technical Report.

The following outlines the major parts of the consultation system:

GOAL CONSULTATION
- QUERY: Title
- QUERY: Audience Attributes
- QUERY: Goal Attributes
- RECOMMEND/QUERY: Goal
- QUERY: Goal Clarification
- RECOMMEND: Content Structure

KINDS CONSULTATION
- QUERY: Content Attributes
- INSTANTIATE/ELABORATE: Kinds Content Structure
- RECOMMEND: Course Organization
- RECOMMEND: Module Functions
- RECOMMEND: Transaction Types
- RECOMMEND: Transaction Characteristics
- DISPLAY: ID Specification for course

PATH CONSULTATION
- INSTANTIATE/ELABORATE: Paths Content Structure
- RECOMMEND: Course Organization
- RECOMMEND: Strategy and Transactions
- DISPLAY: ID Specification for course

3.2 DETAILED DESCRIPTION OF SYSTEM COMPONENTS

3.2.1 GOAL DECISION (SELECT A GOAL)

The first important instructional decision of the ID EXPERT is to help the designer determine the goal(s) of the instruction from which an appropriate content structure, course organization and transactions can be selected. The first set of questions and decisions are relate to selecting an appropriate goal. Some of the information gathered concerning audience and goal attributes is not used to make goal selection decisions but is used later in selecting content structure, course organization or transactions.

3.2.1.1 Query Audience Attributes

ROLE

Will the student use the acquired skill primarily as:
- ... a consumer who needs general information?
- ... a supervisor who directs the technical work of others?
- ... a technician who executes skills to perform a service, produce a product or make repairs.
- ... a problem solver who understands how a device or process works in order to predict outcomes, derive new rules or procedures or design new products or communications.

MOTIVATION

How would you characterize the motivation of the students?
- High! "I want to learn this."
- Unconcerned. "I don't care if I learn this."
- Unmotivated. "I don't want to learn this."

IF MOTIVATION is Unknown.
(The following questions comprise a nested expert which helps the designer determine the motivation of the student.)

Why will the student take this instruction?
- Volunteer, students will have chosen to take this instruction.
- Required, students will be required to take this instruction.

Will this instruction contribute to a job promotion for the student?
- Promotion, the instruction will contribute to a job promotion.
- Unrelated, the instruction will not directly contribute to a job promotion.

Will this instruction contribute to a pay raise for the student?
- Pay raise, the instruction will make the student eligible for a pay increase.
- Unrelated, the instruction will not contribute directly to a pay increase.

Will this instruction enable or require a job change for the student?
- Job change, the instruction will enable or require a job change for the student.
- Unrelated, the instruction will not directly contribute to any change in job.

Did the student request a job change which requires this instruction?
Job change, the student requested the job change which requires this instruction.
No request, the student has not made a specific request for a job change.
No Job Change, the student has requested not to change to the new job.

MOTIVATION DECISION
Based on the information that you have provided we will assume that the student's motivation is HIGH/ UNCONCERNED/UNMOTIVATED.

3.2.1.2 Query Goal Attributes

ORIENTATION

Which of the following best describes what the student will learn?
WHAT is it?
HOW to do it?
How does it WORK?

(The information gathered about role can be used to predict the probable orientation of the instruction. The following questions may be presented rather than asking the orientation question.)

Often the learning appropriate for a consumer is characterized by "What is it"? Does this characterize what you want your students to learn? YES/NO

Often the learning appropriate for a supervisor is characterized by "How to do it"? Does this characterize what you want your students to learn? YES/NO

Often the learning appropriate for a technician is characterized by "How to do it"? Does this characterize what you want your students to learn? YES/NO

Often the learning appropriate for a problem solver is characterized by "How does it work"? Does this characterize what you want your students to learn? YES/NO

OBJECT

The student will be expected to demonstrate the acquired skill with:

... symbols including language, numbers or other symbols.
... object(s) including device(s) or equipment.
... event(s) including processes or procedures.
... person(s) including personal characteristics or roles.

GENERALITY

(The specific set of responses depends on the designers previous specification of the type of object involved in the instruction.)

Will the student be expected to demonstrate the acquired skill with:

... a specific set of symbols which is the same from one occasion to the next?
... several sets of symbols which differ from one occasion to the next?

... a specific device which is the same from one occasion to the next?
... similar devices which differ from one occasion to the next?

... a specific event which is the same from one occasion to the next?
... sets of similar events which differ from one occasion to the next?

... a specific person or group who is the same from one occasion to the next?
... a group or groups of persons who differ from one occasion to the next?

FAMILIARITY

To what extent does the student already know the material to be taught?

HIGH familiarity means that the students have studied the same content before and this course is to refresh their skills.

MODERATE familiarity means that the students have studied similar materials but that the material probably contains some new material or more detailed material than that which has been previously studied.

LOW familiarity means that the students have not studied the material before. All or most of the material to be presented will be new to the student.

MASTERY LEVEL

How well will the students be expected to know the material to be taught?

HIGH mastery means that the student must have the skill at a high level of accuracy and speed. The student will be expected to perform the task with few or no errors.

MODERATE mastery means that the student must have a good understanding of the skill but will probably not be required to perform the task or when it is necessary to perform the task job aids will be available.

LOW mastery means that the student must be familiar with the task in order to supervise someone else who will actually perform the task but that the student will not have to perform the task themself.

3.2.1.3 Recommend/ Query Goals

Based on the information the instructional designer provides about the ORIENTATION, OBJECT and GENERALITY of the instruction the system then recommends one of the following sets of goals from which the designer may select the orienting goal for the instruction. Each set of goals is identified by the values on each of these attributes which leads to the recommendation. The prototype ID EXPERT does not include content structures for most of these goals. (Expanding the ID EXPERT will be a follow-on project.) Those goals for which content structures are included in the prototype ID EXPERT are identified with an asterisk (*).

Goal: wh[illegible].symbol.specific
Which is an appropriate orienting goal for your instruction?
The student will be able to remember a set of symbols (recall symbols).
The student will be able to recite a specific symbolic communication verbatim including verbal information, mathematical information, auditory or musical information (recite).

Goal: what.object.specific
Is the following an appropriate orienting goal for your instruction?
Name the parts and/or functions of a specific object or device (recall parts).

Goal: what.event.specific
Is the following an appropriate orienting goal for your instruction?
The student will be able to remember specific dates, events, places or sources (recall events).

Goal: what.person.specific
Is the following an appropriate orienting goal for your instruction?
The student will be able to remember information about a specific person or persons (recall attributes).

* Goal: what.symbol.general
Which is an appropriate orienting goal for your instruction?
The student will be able to discriminate two or more different kinds of symbols, words or numbers from one another (disriminate symbols).
The student will be able to sort symbols, words or numbers into categories (sort symbols).
The student will be able to identify different symbols, words or numbers as instances of a more general category (generalize symbold).
The student will be able to order a series of symbols, words or numbers relative to some dimension (rank symbols).

* Goal: what.object.general
Which is an appropriate orienting goal for your instruction?
The student will be able to discriminate two or more different kinds of objects (discriminate devices).
The student will be able to sort objects, devices or equipment into categories (sort devices).
The student will be able to identify different objects, devices or equipment as instances of a more general category (generalize devices).
The student will be able to order a series of objects, devices or equipment relative to some dimension (rank devices).

* Goal: what.event.general
  Which is an appropriate orienting goal for your instruction?
  - The student will be able to discriminate two or more different kinds of events, processes or procedures from one another (discriminate events).
  - The student will be able to sort different events, processes or procedures into categories (sort events).
  - The student will be able to identify different events, processes or procedures as instances of a more general category (generalize events).
  - The student will be able to order a series of events, processes or procedures relative to some dimension (rank events).

* Goal: what.person.general
  Which is an appropriate orienting goal for your instruction?
  - The student will be able to identify two or more different kinds of persons based on characteristics or roles (discriminate persons).
  - The student will be able to sort different persons into categories based on characteristics or roles (sort persons).
  - The student will be able to identify different persons as instances of a more general category based on characteristics or roles (generalize persons).
  - The student will be able to order a group of persons relative to their position along some dimension (rank persons).

Goal: how.symbol.specific
Is the following an appropriate orienting goal for your instruction?
- The student will be able to carry out a particular computation which is the same from one occasion to the next (compute).
- The student will prepare a written or symbolic communication which is the same from one occasion to the next (report).

Goal: how.object.specific
Which is an appropriate orienting goal for your instruction?
- * Operate a device (operate).
- * Assemble or disassemble a device (assemble).
- Diagnose and fix malfunctions for a device (trouble shoot).

Goal: how.event.specific
Is the following an appropriate orienting goal for your instruction?
- Execute a fixed sequence of mental or physical actions which are the same from one occasion to the next (perform).

Goal: how.person.specific
Is the following an appropriate orienting goal for your instruction?
- The student will be able to execute a fixed sequence of steps in interacting with a particular person or group of persons (interact).

Goal: how.symbol.general
Which is an appropriate orienting goal for your instruction?
The student will be able to select which of several sets of symbols or symbolic manipulations are appropriate for a given situation where the situation differs from one occasion to the next (select symbols).
The student will be able to diagnose problems and revise (edit) a written or symbolic communication (edit).
The student will be able to execute a series of symbolic manipulation steps in order to produce a symbolic or written communication where the communication differs from one occasion to the next (compose).
The student will be able to execute a series of computations where the specific computations vary from one occasion to the next (compute).

Goal: how.object.general
Which is an appropriate orienting goal for your instruction?
* Operate any of several similar devices or pieces of equipment (operate).
* Assemble or disassemble any of several similar devices or pieces of equipment (assemble).
Select from several options appropriate devices or equipment for a given situation where the situation differs from one occasion to the next (select).
The student will be able to diagnose malfunctions or errors in a given device or piece of equipment and make the necessary repairs (trouble shoot).

Goal: how.event.general
Which is an appropriate orienting goal for your instruction?
Execute a sequence of physical or mental actions which may vary from one occasion to the next (perform).
Select from several options appropriate mental or physical actions for a given situation where the situation differs from one occasion to the next (select actions).
The student will be able to judge the adequacy of mental or physical actions in situations which vary from one occasion to the next(judge performance).

Goal: how.person.general
Which is an appropriate orienting goal for your instruction?
The student will be able to execute a sequence of steps in interacting with a particular person or group in situations which vary from one occasion to the next (interact).
The student will be able to select from several options appropriate actions for interacting with a particular person or group in situations which vary from one occasion to the next (select interaction).
The student will be able to judge the adequacy of the performance of a person or group in situations which vary from one occasion to the next (judge interaction).

Goal: works.symbol.specific
Which is an appropriate orienting goal for your instruction?
The student will be able to describe the outcome from a series of specific symbolic manipulations which do not vary from one occasion to the next (describe symbol).
The student will be able to describe why a specific symbolic structure interacts or functions as it does (explain symbol).

Goal: works.object.specific
Which is an appropriate orienting goal for your instruction?
The student will be able to describe the outcome of a series of interactions of specific objects or devices where the situation is the same from one occasion to the next (describe device).
The student will be able to explain a principle or set of principles which explain(s) why specific objects or devices perform or interact as they do (explain device).

Goal: works.event.specific
Which is an appropriate orienting goal for your instruction?
The student will be able to describe a series of events or processes where the situation does not vary from one occasion to the next (describe event).
The student will be able to explain a principle or set of principles which underlies a specific events or processes (explain event).

Goal: works.person.specific
Is the following an appropriate orienting goal for your instruction?
The student will be able to describe the motives or behavioral antecedents of a particular person or group of persons in a specific situation (describe interaction).

Goal: works.symbol.general
Which is an appropriate orienting goal for your instruction?
The student will be able to predict the outcome from a series of symbolic manipulations (predict solution).
The student will be able to derive or formulate a principle or set of principles which explain(s) why particular symbolic structures interact or function as they do (derive formula).
The student will be able to design and/or develop a communication (verbal, musical, graphic) which transmits a particular message (design communication).
The student will be able to design and/or develop a symbolic structure (program or mathematical formulation) which perform predetermined functions or interacts in desired ways (design logical system).

Goal: works.object.general
Which is an appropriate orienting goal for your instruction?
The student will be able to predict the outcome from a series of interactions of objects or devices where the situation varies from one occasion to the next (predict device).
The student will be able to derive or formulate a principle or set of principles which explain(s) why particular objects or devices perform or interact as they do (derive device).
The student will be able to design and/or develop objects or devices which perform predetermined functions or interact in desired ways (design device).

Goal: works.event.general
Which is an appropriate orienting goal for your instruction?
The student will be able to predict the outcome from a series of events or processes where the situation varies from one occasion to the next (predict event).
The student will be able to derive or formulate a principle or set of principles which explain(s) why particular events or processes occur as they do (derive event).
The student will be able to plan and/or direct a sequence of events to accomplish some specified purpose or function (design event).

Goal: works.person.general
Which is an appropriate orienting goal for your instruction?
The student will be able to predict the outcome from a series of human interactions where the situation varies from one occasion to the next (predict interaction).
The student will be able to derive or formulate a principle or set of principles which explain(s) the actions of a particular person or interpersonal interactions of a group of persons (derive interaction).
The student will be able to plan and/or direct the activities of a person or group of persons (design interaction).

3.2.2 CONTENT STRUCTURE DECISION

Having selected a goal the system has enough information to recommend a type of content structure. For some goals additional information may be necessary to recommend a type of content structure.

3.2.2.1 Query Goal Clarification

ACTIVITY (For HOW.OBJECT goals)

Will the student be expected to execute
... the same steps or actions from one occasion to the next?
... different steps or actions from one occasion to the next depending on the conditions of the device or the functions to be accomplished?

DEVICE.OPERATION (For HOW.OBJECT.GENERAL goals)

Do different kinds of devices operate the same way or differently?
Each kind of device requires the same steps for operation or assembly.
Each kind of device requires different steps for operation or assembly.

3.2.2.2 Recommend Content Structure

Based on the information the instructional designer provides about goal attributes and audience attributes and the selection of a recommended goal the system recommends one of the following content structures. This is not a complete set but merely the content structures recommended by the prototype system. Simple content structures can be elaborated and combined in many ways as may be required by different objectives. Later versions of the ID EXPERT will deal with the various ways to create compound (elaborated) and complex (nested) content structures.

KINDS

This is a complex content structure consisting of a parts taxonomy prerequisite to a kinds taxonomy. (The KINDS consultation of the prototype does not include the prerequisite part of this complex content structure in its present version.)

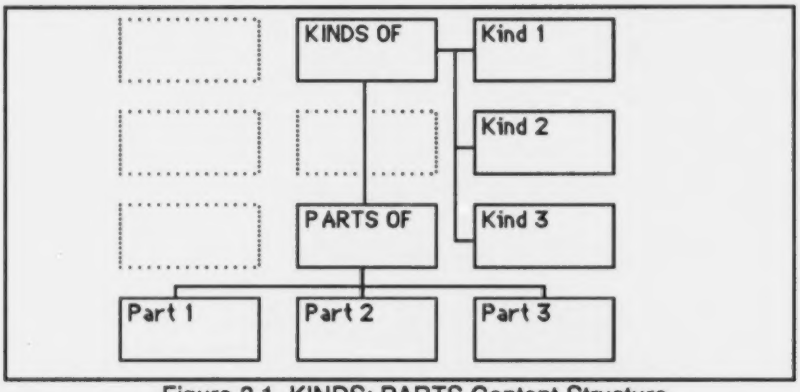


Figure 3.1 KINDS: PARTS Content Structure

PATH: PARTS

This is the simplest of the path content structures. A single series of steps with a parts taxonomy as a prerequisite. This content structure assumes that the same series of steps are executed each time.

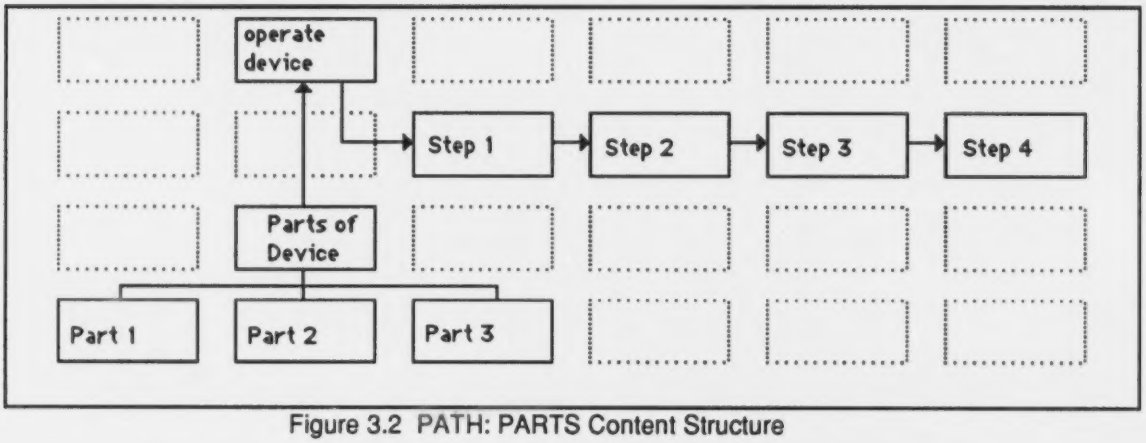


Figure 3.2 PATH: PARTS Content Structure

CONDITIONS/PATHS: PARTS

Many procedures involve a dual process: selecting the function to be accomplished and then executing the steps necessary to execute that function. This type of task involves a CONDITIONS/PATHS complex content structure with a parts taxonomy as a prerequisite.

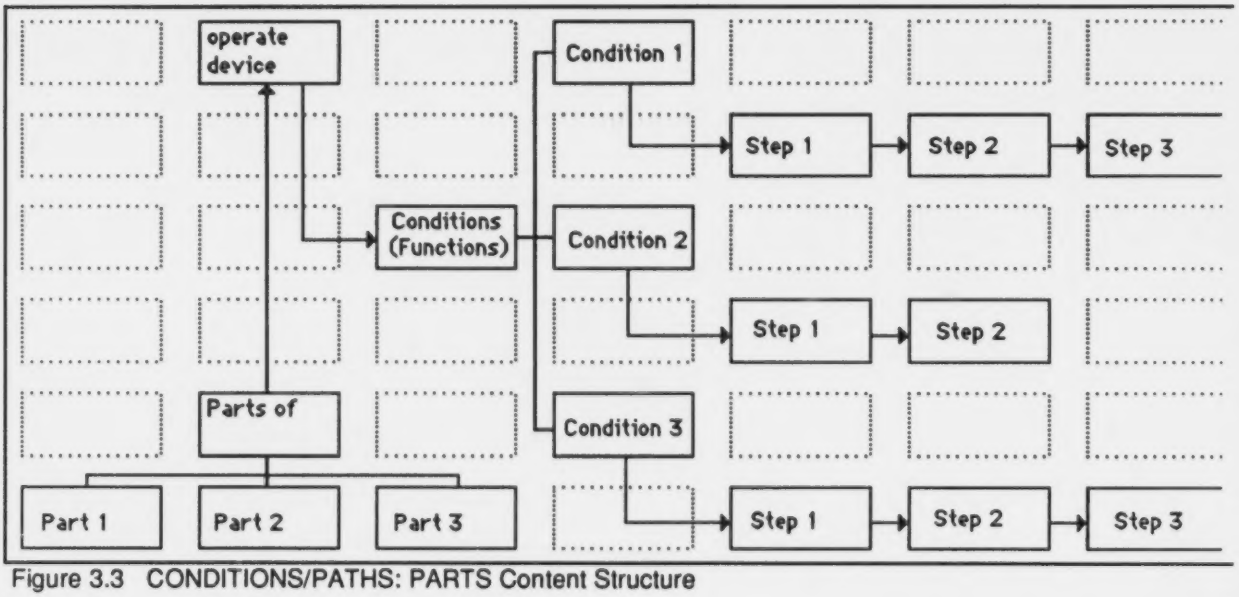


Figure 3.3 CONDITIONS/PATHS: PARTS Content Structure

PATH: PARTS X KINDS

Many procedures can be used with a variety of devices. This content structure assumes that the same steps are executed regardless of which variety of device is used. However in order to use the procedure the student needs to be familiar with a variety of these devices. This complex content structure includes a matrix formed by the combination of a kinds and parts taxonomy as prerequisite to learning the path algorithm.

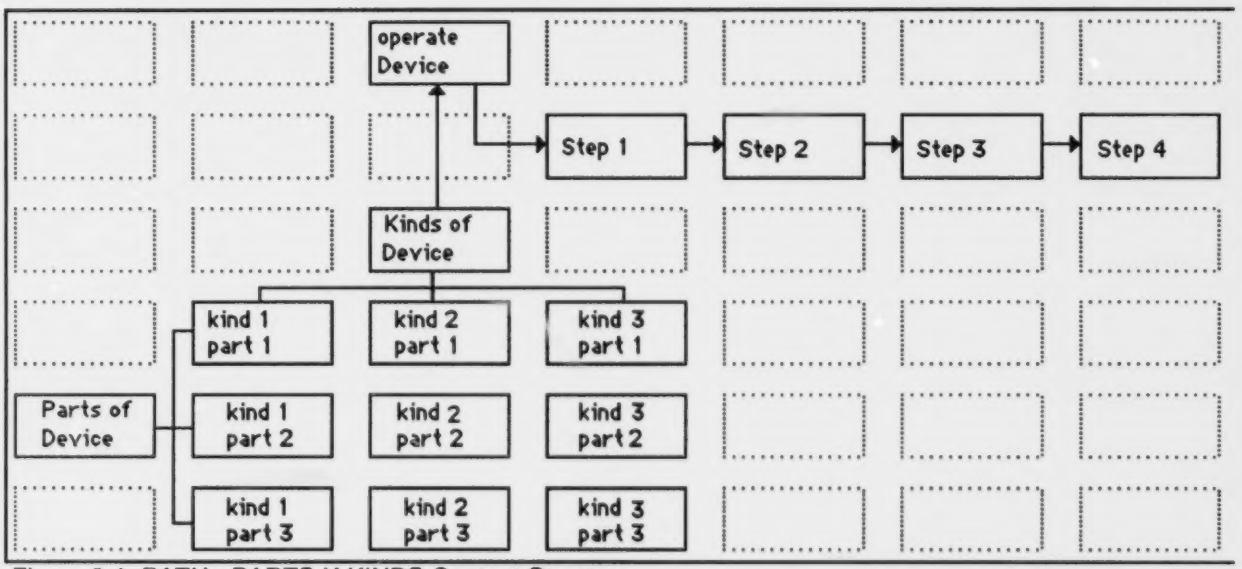


Figure 3.4 PATH: PARTS X KINDS Content Structure

KINDS/PATHS: PARTS

A set of similar devices all may require a different procedure for operation. This complex structure acknowledges this situation and indicates a separate path for each of the kinds of devices. It also recognizes that the parts for each kind of device may differ somewhat and hence shows a parts taxonomy as prerequisite for each kind of device.

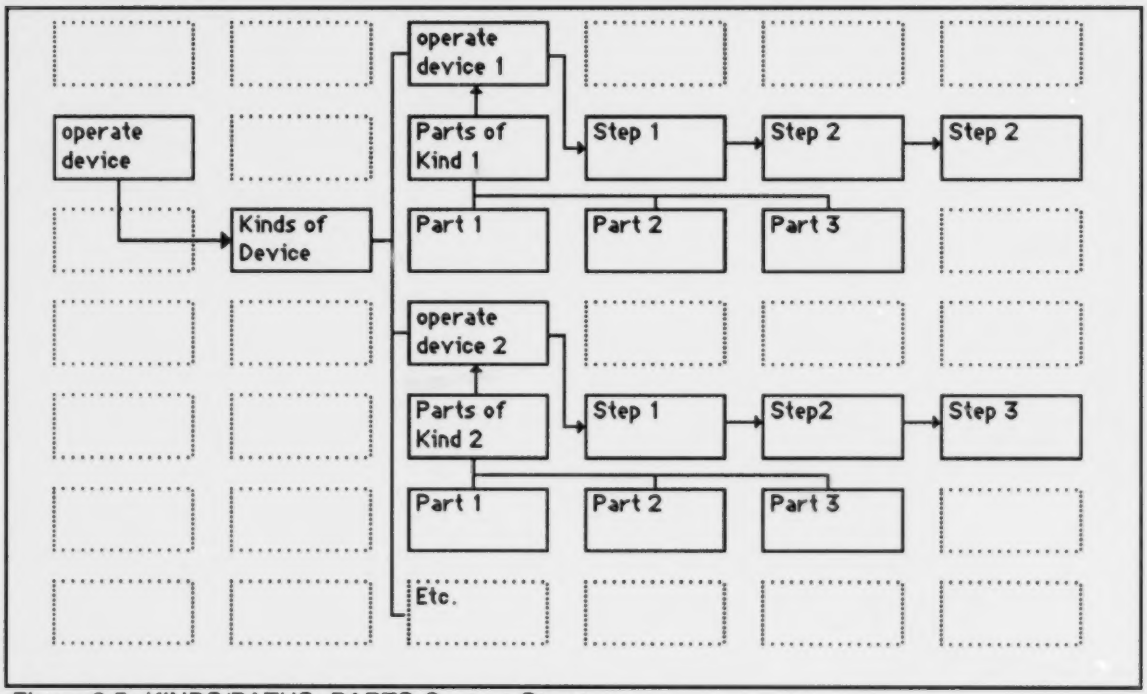


Figure 3.5 KINDS/PATHS: PARTS Content Structure

CONDITIONS/PATHS: KINDS X PARTS

This complex structure acknowledges that in some situations there may be a set of similar devices that all operate essentially the same. All of the devices perform a series of functions hence different conditions with a path associated with each condition. The prerequisite information requires the student to learn the names of the parts for each kind of device. And to learn a set of conditions and the path associated with each condition.

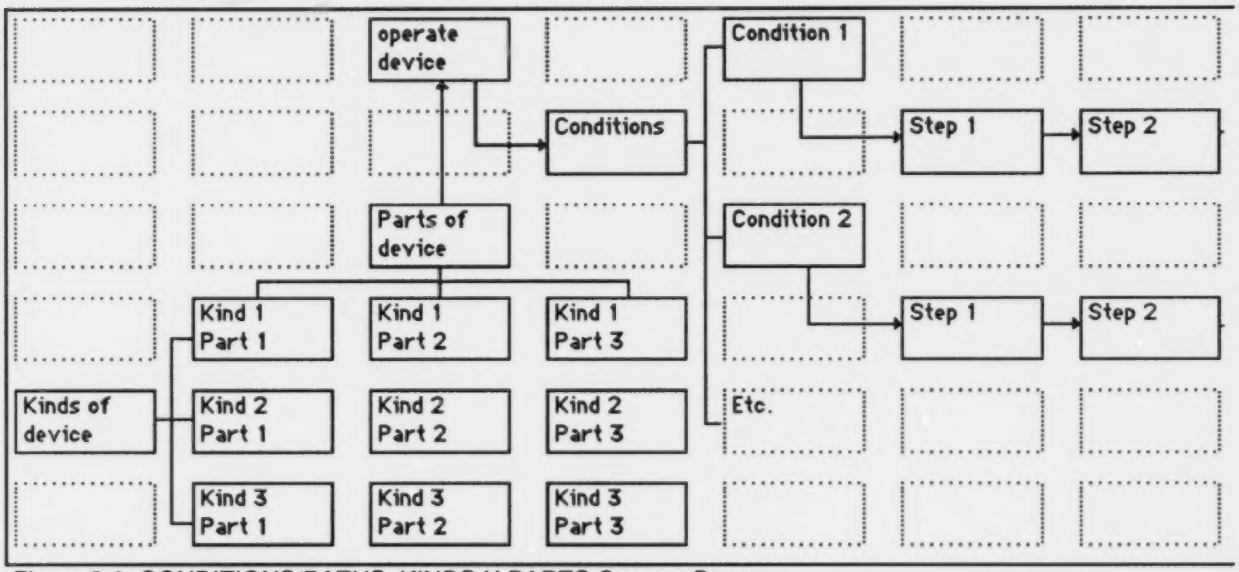


Figure 3.6 CONDITIONS/PATHS: KINDS X PARTS Content Structure

KINDS/CONDITIONS/PATHS: PARTS

This complex content structure is the most complex of those included in the prototype. It is for the case where there are a set of similar devices each with perform a series of functions but where the functions and the paths associated with these functions are different for each kind of device. This complex content structure includes a kinds taxonomy, a conditions (functions) taxonomy for each kind, a parts taxonomy for each kind, and a path for each condition. It involves a number of basic content structures all related in a complex content structure.

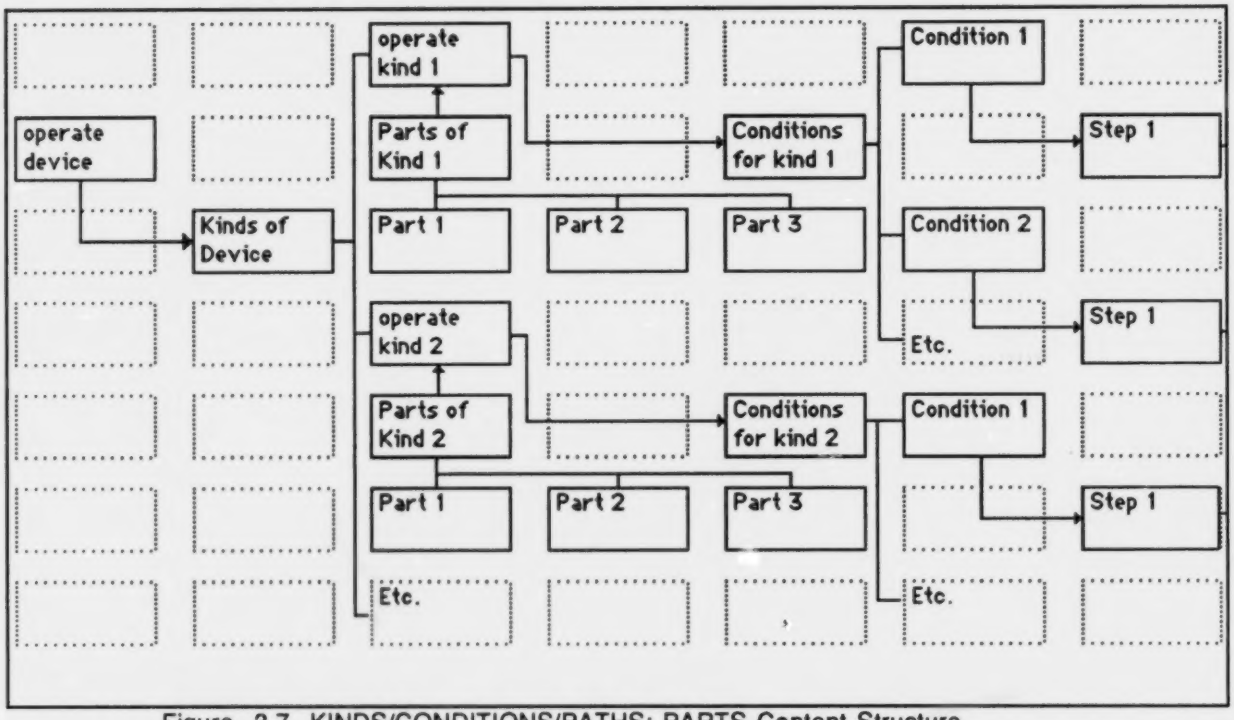


Figure 3.7 KINDS/CONDITIONS/PATHS: PARTS Content Structure

3.2.3 KINDS CONSULTATION

3.2.3.1 Content Structure Elaboration and Instantiation for KINDS Taxonomy

Before it is possible to recommend modules and module sequence (course organization) it is necessary to instantiate the content structure with the content to be taught. Instantiation consists of several activities. The recommended content structure is elaborated to accommodate the content topics. For a kinds taxonomy this elaboration consists of identifying the number of kinds at the each level and providing a name for each kind. Each kind in the first level is then elaborated by identifying kinds of this kind until each level of the taxonomy has been identified.

In the process of identifying the topics (kinds) to be taught the system also seeks additional information about the relationship between the nodes in the content structure. The following questions are used to gather information about the attributes of the specific content which is contained in the content structure.

3.2.3.1.1 Query Content Attributes

RELATIONSHIP (Relationship between coordinate concepts)

What is the relationship between the kinds of <node name>?

INDEPENDENT concepts means that the concepts in a coordinate set are discrete categories that are not likely to be confused with each other. For example, if the superordinate concept is carnivore and two of the concepts in the subordinate coordinate set are carnivorous birds and carnivorous reptiles the two coordinate concepts are independent in that there is little chance that a student will confuse a bird with a reptile.

COORDINATE concepts means that the concepts in a coordinate set are likely to be confused with one another. For example if the superordinate concept is piston pump and two of the concepts in the subordinate coordinate set are lift pump and piston pump the two coordinate concepts are coordinate because the examples of the two kinds of pumps share many similar characteristics and are easily confused with one another.

ORDERED concepts means that the concepts in the coordinate set are not only likely to be confused with one another but that the categories themselves can be ordered on some dimension such as size, age, importance, etc. For example art styles such as baroque, impressionism, romanticism are ordered as to time period. It may be important for the student to not only identify instances as to class membership but to also indicate the order of these instances along the relevant dimension.

OVERLAPPED concepts means that the concepts in the coordinate set do not have nice clean borders with neighboring concepts. Some examples may be hard to classify as to membership in one concept or the other. In other words the boundaries of the categories overlap. For example, political orientation such as liberal vs conservative are concepts which overlap.

CONTINUUM concepts means that the boundaries between the concepts in the coordinate set are ill defined or that there are no boundaries between the various categories. The instances can be ordered along some dimension but that any lines between categories are arbitrary or not easily defined. For example for the superordinate concept "Chess Player" there can be identified a number of kinds of chess players in terms of skill level. The levels however are ill defined but the different kinds of chess players can be ordered from "novice" to "grand master" on the dimension of skill.

FOCUS

Instructional focus indicates the aspect of the relationship in the kinds of taxonomy content structure that will be emphasized.

What is the primary instructional focus for learning about these kinds of <node name>?

IDENTIFY focus means that the primary goal of the instruction is to have students identify items as examples or nonexamples of a single concept without regard for the other concepts in the coordinate set. For example, the coordinate sets may be carnivorous birds and carnivorous reptiles. The student needs to learn to discriminate carnivorous birds from those which are not but does not learn to to discriminate carnivorous birds from carnivorous snakes.

DISCRIMINATE focus means that the primary goal of the instruction is to have students discriminate instances of the various concept categories in the coordinate set from one another. For example if the coordinate concepts are "Sloop sail boats", "cutter sail boats", etc. then a discriminate focus means that students will be able to correctly identify a given sail boat as a sloop or a cutter.

RANK focus means that the primary goal of the instruction is to have students rank instances of a superordinate concept along some dimension represented by coordinate concepts. A ranking focus is more appropriate than a discriminate focus when the coordinate concepts are ordered or form a continuum. For example Chess Players form a continuum on the dimension of skill level from novice to grand master. Two or more chess players can be ranked with regard to skill irrespective of their category.

GENERALIZE focus means that the primary goal of the instruction is to have students identify members of two or more coordinate concepts as members of a more general superordinate concept. For example, students may already be able to discriminate hawks from snakes but may not know that both hawks and snakes are instances of the general concept carnivore.

KINDS of focus means that the primary goal of the instruction is to have students identify instances of a subordinate concept as instances of a superordinate concept without regard for other concepts in the coordinate set. For example, for the superordinate concept Carnivore and the subordinate concepts carnivorous fish or carnivorous reptile, a kinds of focus would require the student to identify instances of fish as instances of carnivore without considering instances of reptiles.

PLACE.HOLDER is really not a focus but a category which facilitates the organization of content. Whenever you have more than 5 or 6 different coordinate concepts under a single superordinate concept it is better if these concepts can be grouped together on some basis so that the resulting modules do not include too much content for the student to consider at one time. In such cases a placeholder category can be used to organize the content. A placeholder means that there is no intent to teach the placeholder concepts but merely to use them to conveniently organize the content.

INTEGRATION

Are the concepts integrated or independent?

INTEGRATED. Many concepts, even though they are learned separately, must in the real world be applied simultaneously. That is the student must use all of the concepts at once. For example, finding writing errors in text requires the student to simultaneously apply many different coordinate concepts. This is an INTEGRATED task.

INDEPENDENT. Some tasks are not integrated and the concepts are considered one at a time. For example indicating whether a given bird is carnivorous or not. INDEPENDENT means that the student can consider the concepts rather independently.

EMBEDDED

Are the concepts in the coordinate set embedded or isolated?

EMBEDDED. A concept is EMBEDDED when instances usually appear in context and the classification of a given instance requires the context for classification. Examples include "choosing a pronoun possessive or pronoun contraction such as its vs it's" , "identifying poetic meter such as iambic or trochaic", "identifying whether the slope of a graph is negative or positive", etc.

ISOLATED. A concept is ISOLATED when instances can easily be presented without surrounding context. Examples include "type of sail boat such as sloop vs cutter", "kind of cloud such as nimbus vs cumulus", "type of pump such as siphon vs centrifugal", etc.

ABSTRACT

Are the concepts in the coordinate set abstract or concrete?

ABSTRACT means a defined concept. Examples of abstract concepts are difficult to show directly and must usually be inferred from events or situations. Examples include "justice", "buoyancy", "voltage", etc.

CONCRETE means an object or event for which an example can be directly observed. Examples include "sloop sail boat", "iambic poetic meter", "nouns", etc.

ATTRIBUTES

Are the concepts in this coordinate set defined by many or few attributes?

FEW. Concepts are defined by critical attributes. Concepts which are defined by only a few attributes are easier to learn than concepts which are defined by many attributes. For example the concept "Sloop sail boat" is defined by

three attributes -- one mast, two or more sails, and the mast located in aft of the bow. This concept is defined by FEW attributes.

MANY. The concept "Conservative" is defined by many complex attributes including "resistant to change, support of free market, support for big business, resistant to government social service programs, resistant to government regulation of business, support of lower taxes, etc. This concept is defined by MANY attributes.

REPRESENTATION

Are the concepts in this coordinate set represented by a document or illustration?

DOCUMENT means that examples of the concept are best represented via written symbols including words, mathematical expressions and other communication that uses numbers or the alphabet.

ILLUSTRATION means that examples of the concept are best represented via some graphic presentation such as a chart, drawing, or picture."

3.2.3.2 Recommended Course Organization

Having instantiated the content structure and gathered additional information about the relationships between the elements in the content structure the system is ready to recommend course organization. Course organization indicates the required modules, content for each module, objectives for each module, module sequence and the necessary menu/decision control structures. The system makes this course organization recommendation specific to the content specified in the content structure.

MODULE SCOPE

A module can assume three values related to the amount of content included in the module. These are pre-integrative, post-integrative and instructional.

A PRE-INTEGRATIVE module usually serves as an overview or preassessment for the content of several instructional modules.

A POST-INTEGRATIVE module serves as a review or assessment for the content of several instructional modules.

An INSTRUCTIONAL module is the instruction for a given set of content elements.

MODULE TYPE

Instructional modules may be one of four types which determine the content elements to be included in the module. These are single-node, coordinate-set, coordinate-superordinate and superordinate-node. The content of these modules is indicated by the dotted boxes in the following diagrams:

Single-node:

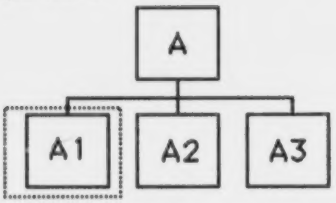


Figure 3.8 Single-Node Module

Coordinate-set:

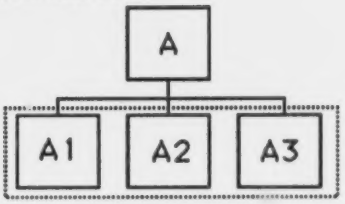


Figure 3.9 Coordinate-set Module

Coordinate-superordinate:

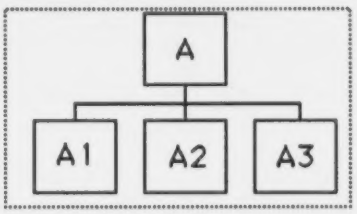


Figure 3.10 Coord-SuperOrd Module

Superordinate-node:

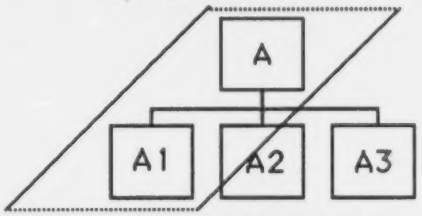


Figure 3.11 SuperOrd-Node Module

MODULE SUBJECT MATTER CONTENT

Subject content is a list of the content elements from the content structure that are included in the module. This list can be from a single node in the content structure or may include the content from several nodes in the content structure.

MODULE OBJECTIVE

A module may have one or more objectives. The objectives for modules required to teach a kinds taxonomy will be one or more of the following stated in terms of the content identified for the module.

OBJ-Identify. Student will be able to identify instances of [A].

OBJ-Discriminate. Student will be able to discriminate instances of [A1], [A2] and [An] from one another.

OBJ-Order. Student will be able to order instances of [A] on the dimension [C] from [Cleft] to [Cright].

OBJ-Generalize. Student will be able to identify instances of [A1] and instances of [A2] as instances of [A].

OBJ-Kinds of. Students will be able to identify instances of [A] as instances of [A1], [A2] and [An].

MENU DECISION STRUCTURE

Menu/decision structures indicate a decision point from which two or more sequences are available to the student. The decision as to which path to follow can be either a learner or an instructional system decision. The prototype ID Expert does not yet make recommendations concerning the decision rules for these menu/decision control structures.

3.2.3.3 Recommend Module Functions

Modules serve one or more instructional functions. While the expert system can make suggestions the final selection of the functions for a module to serve must be the designer's decision. The following are brief descriptions of each of the recommended functions.

OVERVIEW is used primarily for integrative functions to introduce a new topic or set of topics.

NEW.PRESENTATION is used to teach material that is new to the student, that has not been previously learned.

OLD.REMEDIATION is used to teach material that has been previously learned but may have been partially forgotten.

EARLY.PRACTICE is used to help the student acquire the skills being taught with significant amounts of learner guidance and support.

LATE. PRACTICE is used to help the student increase their accuracy and performance level on the skills being taught. Late practice contains little or no learner guidance and requires higher levels of skill than early practice.

REVIEW is used primarily for post integrative modules which summarize several topics which have been previously taught perhaps as separate modules.

ASSESSMENT.DIAGNOSIS is used for testing the students skills. In preintegrative modules the function may be to diagnose the students skill level for purposes of selecting subsequent modules. For postintegrative modules the function may be to assess the students skill acquisition from previous modules.

3.2.3.4 Recommended Transaction Decisions

A given module may include several transactions for each function. The following provides a very brief description for each transaction type that is recommended.

SYNTHESIS the student is presented the kinds of content structure and shown the relationships between the various concepts. Figure 3.12 and 3.13 illustrates an explore transaction where the student can point to any node in the kinds of taxonomy and be shown a definition and example of the node or be shown an instance and attempt to identify it as an instance or non instance of the node.

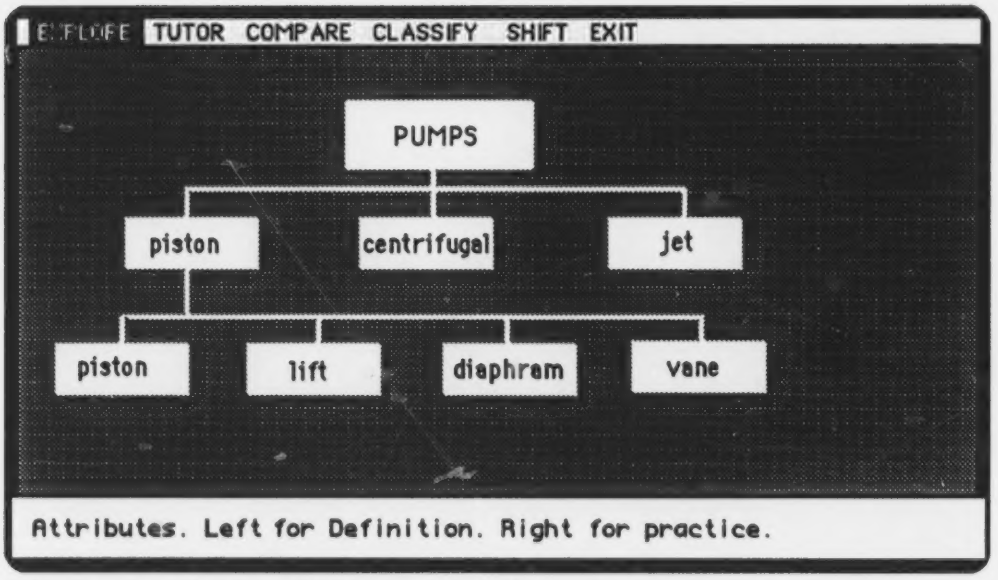


Figure 3.12 An example of an Explore Synthesis transaction

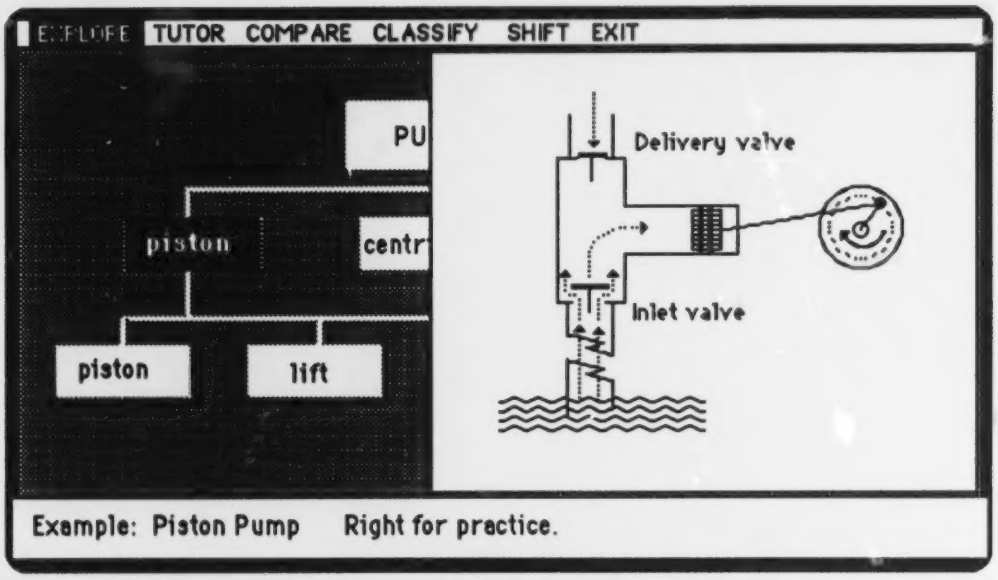


Figure 3.13 An Explore Synthesis transaction showing an example

SUMMARY the student is presented a list of the definitions for each of the concepts taught. No illustration is provided.

EXPOSITION the student is shown definitions and examples for each of the concepts being taught. Figure 3.14 indicates the definition and an example from a tutorial transaction.

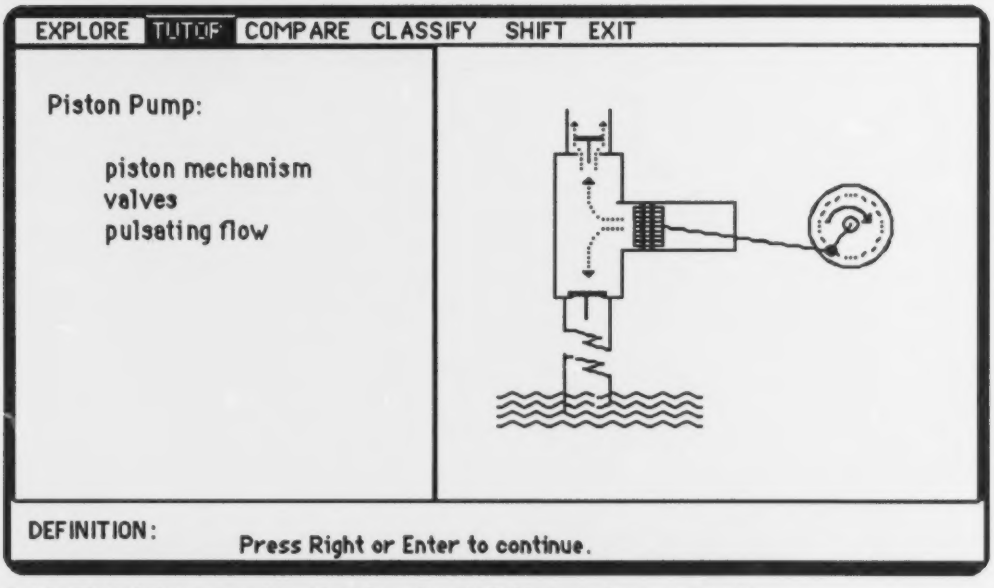


Figure 3.14 Tutorial transaction showing the definition and an example

CONVERSATIONAL.TUTORIAL the student is asked a series of rhetorical questions directing attention to the critical attributes both in the definitions and the examples presented. The conversational tutorial is not illustrated.

EDIT the student is presented a document (text) and asked to identify incorrect instances of the concepts being taught and to correct these instances. The Edit transaction is not illustrated.

COMPARE.CONTRAST in compare mode the student is shown a reference example of a given concept and then a series of divergent examples are compared to the reference example. In contract mode the student is shown contrasting examples from two or more of the coordinate categories. Figures 3.15 through 3.19 illustrate a compare and contrast transaction.

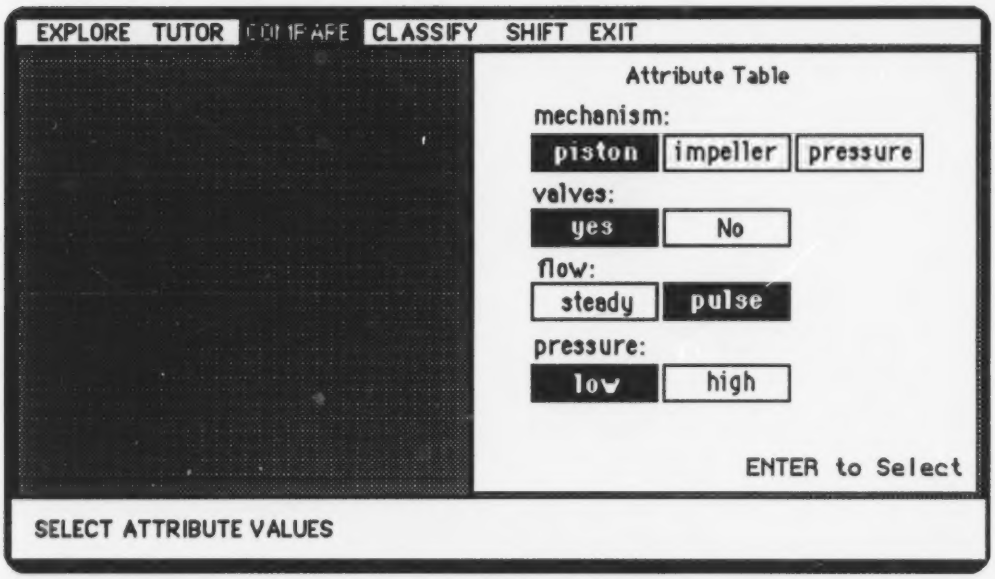


Figure 3.15 Compare Contrast Transaction showing attribute table.

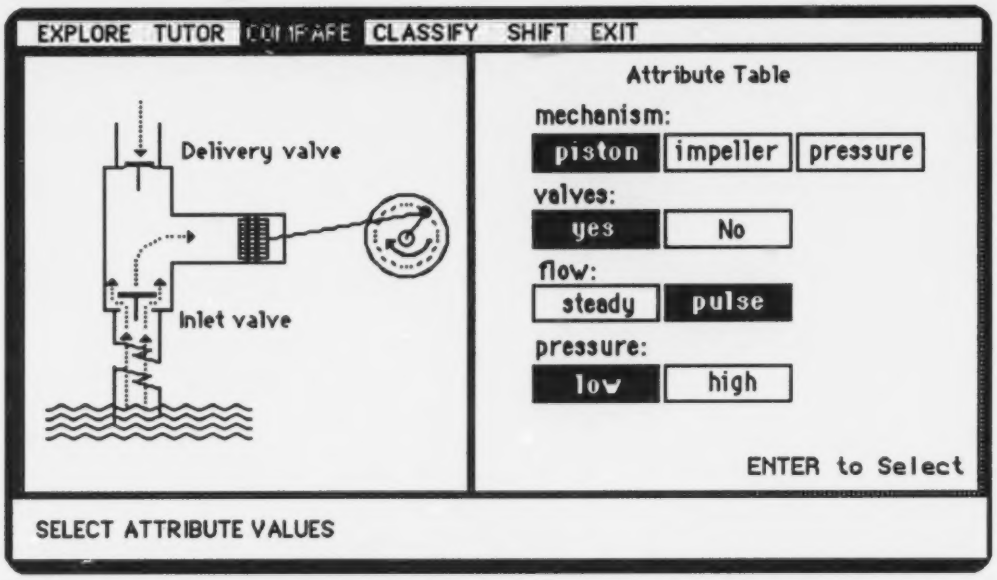


Figure 3.16 Compare Contrast transaction showing an example with the attribute table.

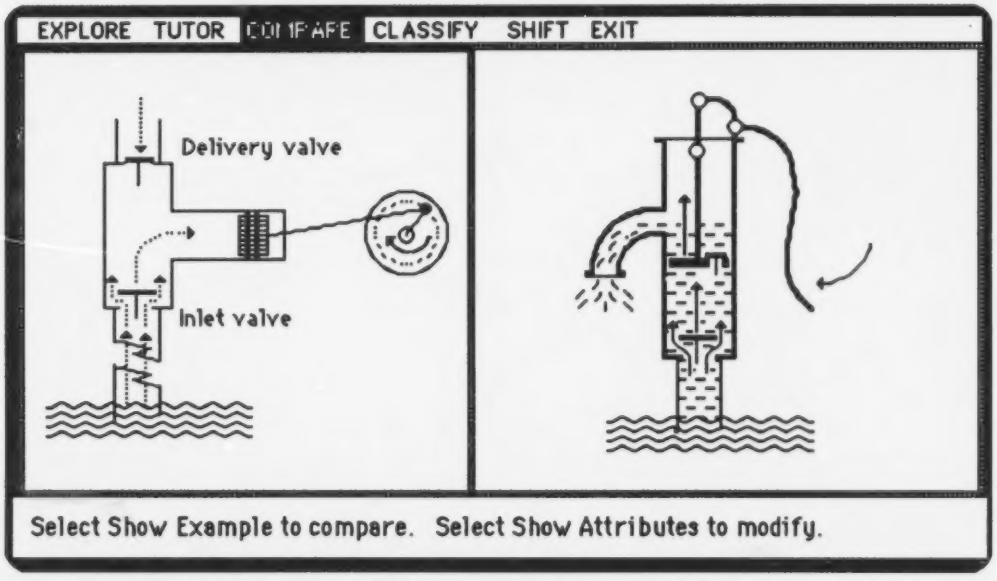

EXPLORE TUTOR COMPARE CLASSIFY SHIFT EXIT
Delivery valve
Inlet valve
Select Show Example to compare. Select Show Attributes to modify.

Figure 3.17 Compare Contrast transaction showing a comparison example.

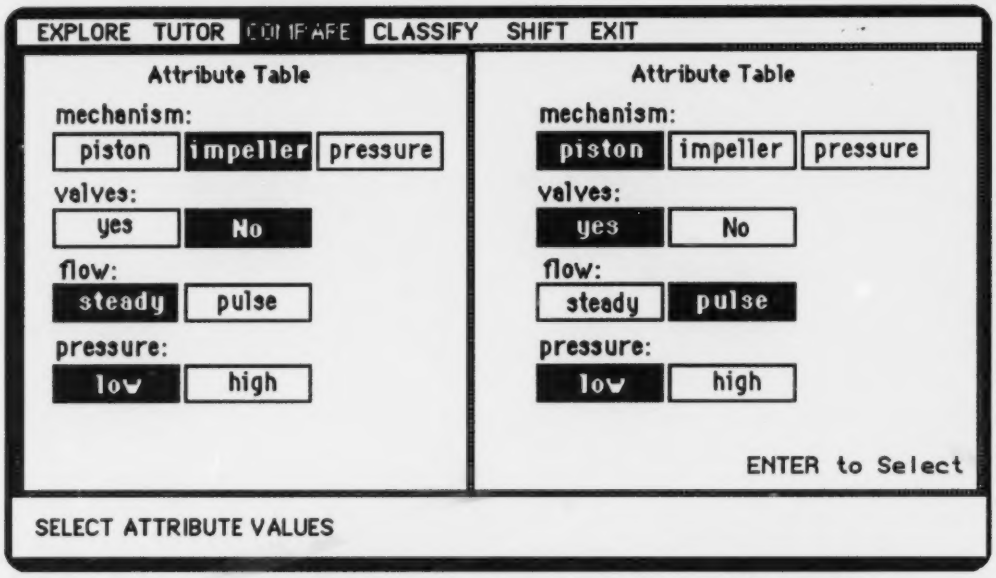


Figure 3.18 Compare Contrast transaction showing two attribute tables.

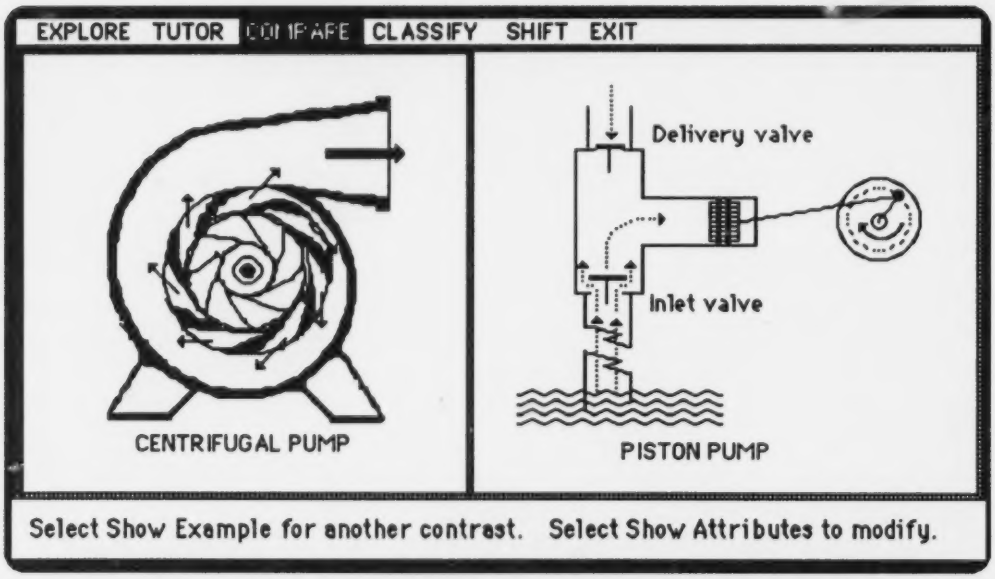

EXPLORE TUTOR COMPARE CLASSIFY SHIFT EXIT
CENTRIFUGAL PUMP
Delivery valve
Inlet valve
PISTON PUMP
Select Show Example for another contrast. Select Show Attributes to modify.

Figure 3.19 Compare Contrast showing contrasting examples.

INTERPRETE the student is given a graphical representation and asked to identify instances of a given concept within the graphic or to make changes so that the graphic is a more adequate representation of a given instance. Not illustrated.

SORT the student is shown a number of instances and asked to identify the correct concept category for each instance. Not illustrated.

LABEL the student is shown a number of instances and asked to provide the correct concept label for each instance. Not illustrated.

RANK the student is shown a number of instances and asked to arrange them in order on a dimension on which the coordinate concepts overlap. The student may also be presented a number of instances and asked to arrange them from best and worst as examples of a given category. Not illustrated.

QUESTION the student is asked multiple choice, short answer, matching or true false questions about definitions or examples of the concept(s). Not illustrated.

3.2.3.5 Recommend Transaction Characteristics

Transaction Sequence. Most of the transaction types identified for teaching concepts involve a set of coordinate concepts. Transaction sequence determines the order in which these concepts will be introduced by the transaction.

Sequential means that each concept is taught and then the next concept it taught.

Simultaneous means that all of the concepts in the set of coordinate concepts are taught at the same time.

Decision Algorithm means that the attributes are taught in the order that the user should use the decision algorithm in making the classification. After all of the attributes have been taught then the student will have acquired the ability to make the classification of the entire set of coordinate concepts.

Transaction Presentation Mode. Transaction presentation refers to whether the primary orientation of the presentation is to present information to the student or whether the primary orientation of the presentation is to for the student to demonstrate his/her understanding of the material.

Expository means that the primary purpose of the transaction is to present information to the student, to do the initial teaching which enables the student to understand the concepts being presented.

Inquisitory means that the primary purpose of the transaction is to assess the students understanding of the concepts presented or to provide an opportunity for the student to use the information presented to classify new examples.

Mixed means that the activities of the transaction move back and forth between expository and inquisitory modes.

Transaction Control Mode. The presentation of optional information can be controlled by the learner or can be presented by the system without providing an option for the learner.

Learner control means that the learner determines the order of the concepts studied within either the coordinate structure or the decision algorithm or that the learner can access optional information at his/her request.

System control means that the system selects the next activity or next piece of information for the student.

Transaction Content Representation. Different kinds of information are necessary to instantiate the various types of transactions. Transaction Content Representation indicates which kinds of information must be present as part of the content structure or associated with the content structure in order for the transaction to be implemented.

Required/Optional indicates whether the content representation is required by the transaction or optional. Optional information becomes required when the student is given learner control over optional information.

Taxonomy refers to the instantiated kinds content structure diagram which is presented to the student by some transactions.

Definition refers to a statement associated with each concept in the coordinate set which identifies the superordinate concept and the attributes which distinguishes each concept of the coordinate set from other members.

Alternative Definition refers to a restatement of the definition or a presentation of the definition in some alternative format such as a chart or graph.

Attribute definition refers to a definition for each of the key attributes in the main definitions. Attribute definitions are a form of hypertext.

Decision algorithm refers to the decision tree which guides the student through the defining attributes of the concept. Some transactions require the presentation of the decision algorithm to the student or use of the decision algorithm to order the presentation of elements to the student.

Examples refer to instances of each of the members of the coordinate set. Many transactions require a set of such examples which are divergent from one another.

Attribute isolation refers to attention focusing material which isolates the critical attributes of an example or shows why the example is indeed a member of the concept class under consideration.

Context refers to settings, background, other content in which is may be necessary to embed the instances. For example, math story problems require a context. English grammar requires a context.

Question refers to a pool of questions of some format (multiple choice, true/false, short answer, matching) which have been constructed to assess the student's understanding of the concepts being taught.

3.2.4 PATHS CONSULTATION

3.2.4.1 Content Structure Elaboration and Instantiation

Before is is possible to recommend modules and module sequence (course organization) it is necessary to instantiate the content structure with the content to be taught. Instantiation of a path algorithm for the prototype is relatively straight forward. The user/designer is asked how many steps are involved in the main path. The system then gets a name or description for each step. Then for each step thus identified the user is asked whether the learner can perform this step with only directions or by using a job aid. If not the user is asked to elaborate (identify substeps) for each step thus elaborating the content structure. The current version of the prototype does not allow the user to identify branching procedures or procedures containing loops. These forms of elaboration will be incorporated into later versions of the system.

After all of the steps have been elaborated the system is ready to make recommendations about course organization and transactions.

3.2.4.2 Recommended Course Organization

MODULE SCOPE

A module can assume three values related to the amount of content included. These are pre-integrative, post-integrative and instructional.

A PRE-INTEGRATIVE module usually serves as an overview or preassessment for the content of several instructional modules. It's most important use is to allow the student to see a complex procedure in its entirety before studying the subparts.

A POST-INTEGRATIVE module serves as a review or assessment for the content of several instructional modules.

An INSTRUCTIONAL module is the instruction for a given set of content elements, usually a series of steps which is some part of the procedure.

MODULE TYPE

There is only one type of instructional module for a path algorithm, this module includes a series of steps as identified on the content structure. The limitation on number of steps in instantiating the content structure limits the number of steps taught in any single module to 7± 2 steps. Some modules also include naming the parts of the device as part of the module.

MODULE OBJECTIVES

A module can have one or more objectives. The objectives for modules required to teach a path algorithm will be one or more of the following stated in terms of the content identified for the module.

Obj-Execute. Student will be able to execute the steps for <name of procedure or step>.

Obj - Name. Student will be able to name the parts of <device>.

MENU DECISION STRUCTURES

Menu/decision structures indicate a decision point from which two or more sequences are available to the student. The decision as to which path to follow can be either a learner or an instructional system decision. The prototype ID Expert does not yet make recommendations concerning the decision rules for these menu/decision control structures.

3.2.4.3 Recommended Strategy

A given module usually contains several different transactions. The instruction for a module consists of the various transactions and the control structure which determines the strategy (transaction selection and sequence) for the student. The variety in control structure and transaction selection depends on the function of the module, hence each of following transaction sets are designed for a particular function for the module.

FAMILIARITY

We often design instruction as if all of the students who will learn the material need to know every detail of the content. Often, however, especially for general education (consumers) and supervisors a "lick and a promise" instruction is sufficient. The student needs to be "familiar" with the content but does not need to master the details. It is sufficient if the student recognizes certain procedures but may be unable to execute the procedure or name the parts or functions of the device. The following strategy is designed to promote only familiarity.

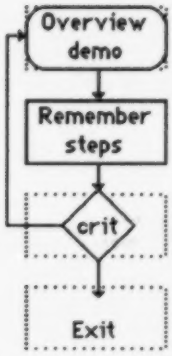


Figure 3.20 Familiarity instruction

The criterion decision sets the score for the student in remembering the steps and the student does not read the described below the demo is repeated and the student is quizzed on recognizing the steps a second time. The rules for establishing criterion can be specified but are beyond the scope of the prototype ID Expert.

BEST COPY AVAILABLE

REMEDIATION

Often students are already familiar with the content of the instruction. In this case the purpose of the instruction is to review the material and provide necessary remediation for those students who may not be able to meet the criterion. The nature of the remediation depends on the motivation and degree of familiarity of the student.

The following strategies show a remediation strategy where the remediation is one of the forms of basic instruction described below: Learner control basic instruction, structured learner control basic instruction or system control basic instruction. The decision as to the form of the basic instruction remedial strategy to be followed can be made prior to the instruction or on line for each individual student.

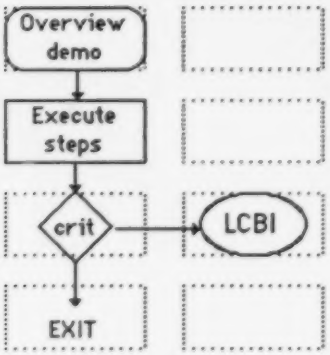


Figure 3.21 REM: LCBI

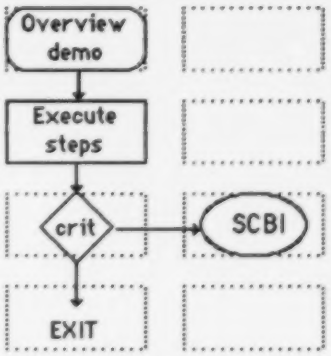


Figure 3.22 REM: SCBI

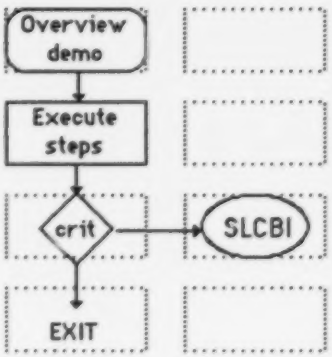


Figure 3.23 REM: SLCBI

LEARNER CONTROL BASIC INSTRUCTION

The basic instruction strategy involves complete instruction assuming that the student is unfamiliar with the material to be taught and must perform at a high level of mastery. Learner control basic instruction assumes a very high level of motivation and the ability of the student to determine what aspect of the task to study next. All of the transactions are available to the student at his/her choice.

The degree of learner control can be determined before the instruction or on line via some type of advisor. The learner control function also assumes some advisor which informs the student of his/her progress and determines a criterion for exit. The advisor may also choose to turn off a given option if the student's performance warrants such control. Thus this learner control strategy, if implemented with an on-line advisor, may have considerable variety in what transactions are available to a given student at a given time. The rules for such an on-line advisor are beyond the scope of the prototype system.

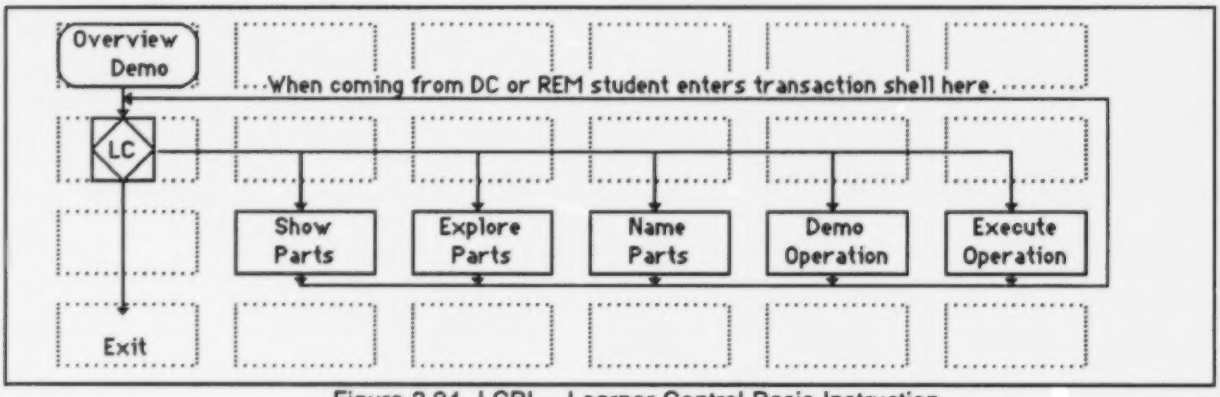


Figure 3.24 LCBI -- Learner Control Basic Instruction

STRUCTURED LEARNER CONTROL BASIC INSTRUCTION

For some students complete learner control is difficult to handle. They need more structure in the strategy available to them. The structured learner control basic instruction strategy is is a compromise between LC and system control (described in the next section). The student is required to learn the names of the device before attempting to learn the operation of the device. However, within each of these submodules the student has the freedom to decide when to practice and when to study the expository materials.

The learner control decision contains a criterion to determine when the student is ready to learn the operation or ready to exit the module. Like the LCBI this strategy could also be implemented with an intelligent advisor which not only provides information about what the student has done but also provides strong advice about what the student should do next, or even turns off some transactions if it is felt that the student's access should be limited until some criterion is met. The rules governing the on-line decisions of this advisor are beyond the scope of the prototype system.

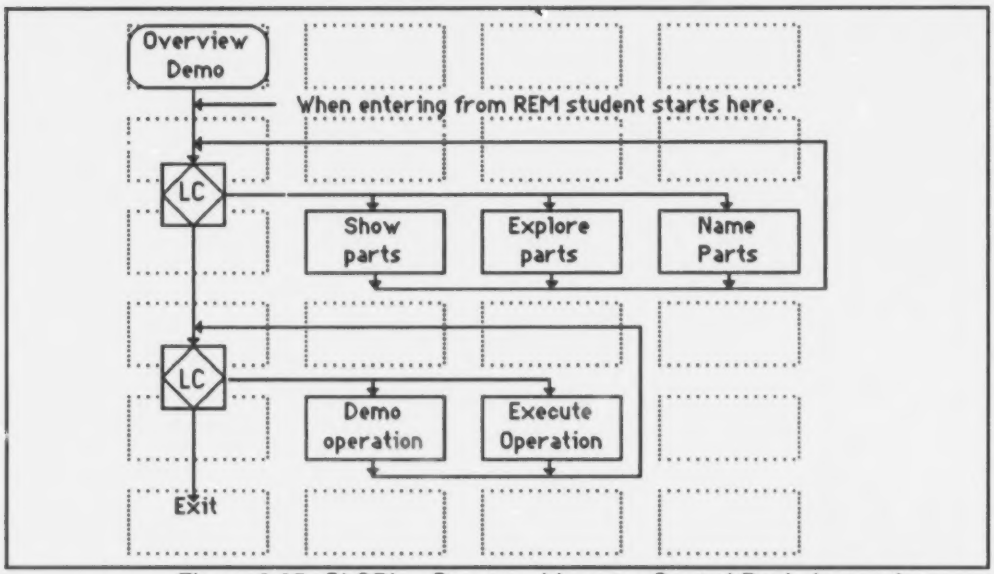


Figure 3.25 SLCBI -- Structured Learner Control Basic Instruction

SYSTEM CONTROL BASIC INSTRUCTION

For students with less motivation or more externally directed (locus of control) the strategy needs to be more structured with less options for the student. The following is the system controlled strategy which resembles more linear instruction.

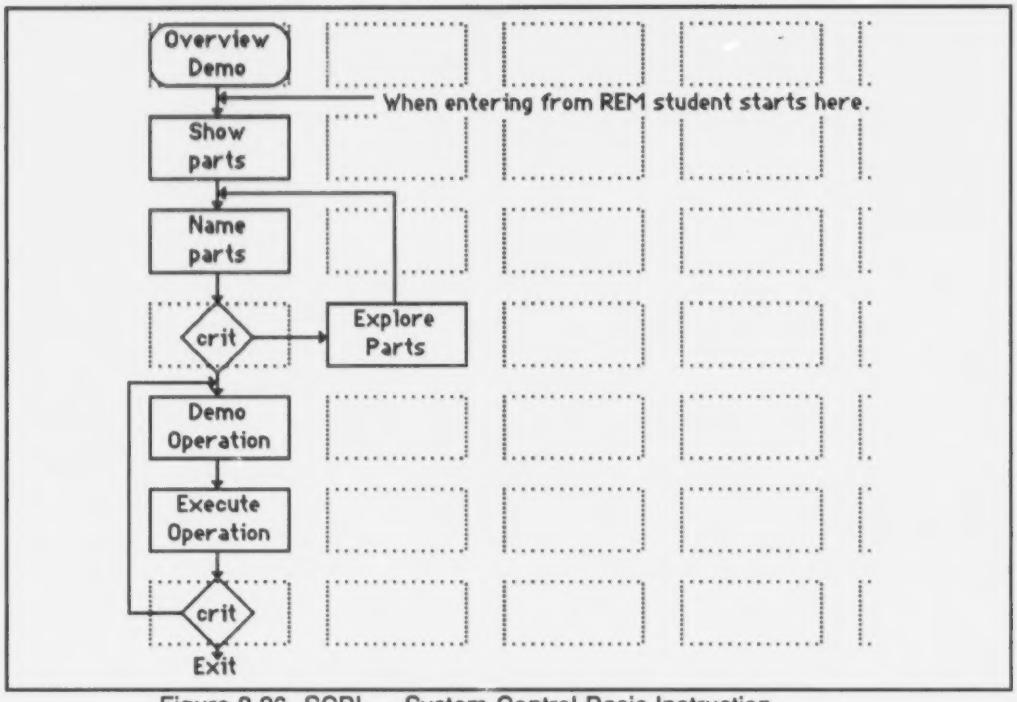


Figure 3.26 SCBI -- System Control Basic Instruction

MENU DESICION STRUCTURE

DEPTH CHOICE (DC). While a student (consumer or technician) may only need an overview type of familiarity strategy, if they are highly motivated, they may wish to put forth the extra effort to learn the material in depth. This decision obviously depends on other factors such as the availability of the more in depth instruction, sufficient time to learn the material at greater depth without sacrificing the learning of other material, etc. The depth choice is merely learner control about the type of strategy with which to learn. Like other types of learner control this choice can either be on line or up-front. The rules governing the DC advisor are beyond the scope of the prototype system.

The depth choice is illustrated for both remedial (for students already familiar with the material) and familiarity strategies combined with LCBI. Only LCBI is indicated because depth choice is usually only appropriate for highly motivated students.

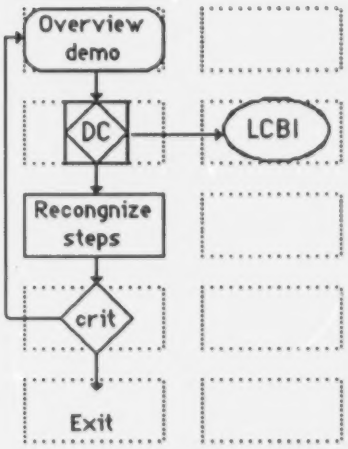


Figure 3.27 DC FAM:LCBI

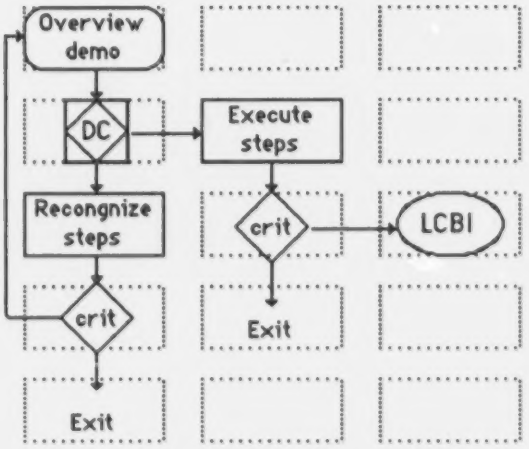
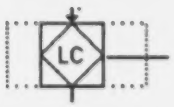


Figure 3.28 DC FAM/REM: LCBI

ADVISED LEARNER CONTROL



This symbol indicates a learner control menu as part of the strategy. As indicated for the transaction strategies below this menu may appear as a menu bar on the display allowing the student to make any of the transaction choices shown as following from a LC choice.

This learner control menu, however, is merely the student interface with a more complex on-line advisor. The specifications of the rules governing such an on-line advisor are beyond the scope of the prototype system.

An advisor would include the exit criterion, which determines when the student can choose the quit option and move to the next part of the module strategy or to the next module. An advisor would also include guidance messages which would warn the student if they were neglecting one transaction or spending too much time on one transaction. The advisor would have the power to make certain transaction choices unavailable

under certain circumstances. With an intelligent on-line advisor the LCBI and SLCBI strategies illustrated above could really be variations of a more dynamic advisor based learner control strategy.

SYSTEM CONTROL

System control is the absence of menu choices for the student. On the system control strategy the menu is replaced by a "criterion" decision structure. This is a message giver which indicates to the student when they can proceed or if they must repeat or redo some previous transaction.

In fact LCBI and SCBI represent the two ends of the learner control continuum. With an intelligent on-line advisor both options and all the various in between stages are available. The decision on the variation to make available to a particular student would be governed by the advisor rules. It should be noted that some of those rules are the same as those included in this prototype ID Expert. However, the determination of motivation and familiarity and role may be gathered directly from the student rather than from the designer. In addition other performance and attitude indicators would provide attributes for the advisor rules.

3.2.4.4 Recommended Transactions

SHOW PARTS

Show parts is an expository presentation in which each of the parts of the device are shown to the student one by one along with their name and/or function. The speed of the presentation can be timed but is usually under learner control where the student requests when to show the next part. This is the primary presentation device for learning the parts of the device.

The menu bar at the top of the screen shows each of the possible transactions but in the following diagram those transactions except SHOW are dimmed and unavailable to the student. Under learner control (LCBI) all transactions are available. Under systems control (SCBI or SLCBI) some of the transactions are not available. There names are either dimmed or removed from the menu under these conditions.

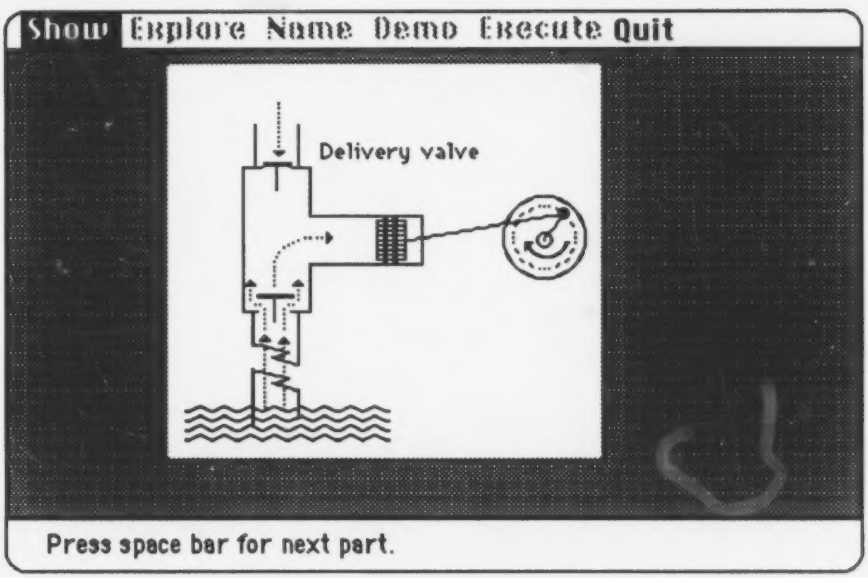


Figure 3. 29 Show Parts Transaction

EXPLORE PARTS

Explore parts is similar to show parts except that the learner has control over which part to be shown next. The learner points to a part and the system gives the name and/or function of the part to the student. This transaction is useful after the student has attempted to learn the parts and needs to review those of which he/she is uncertain.

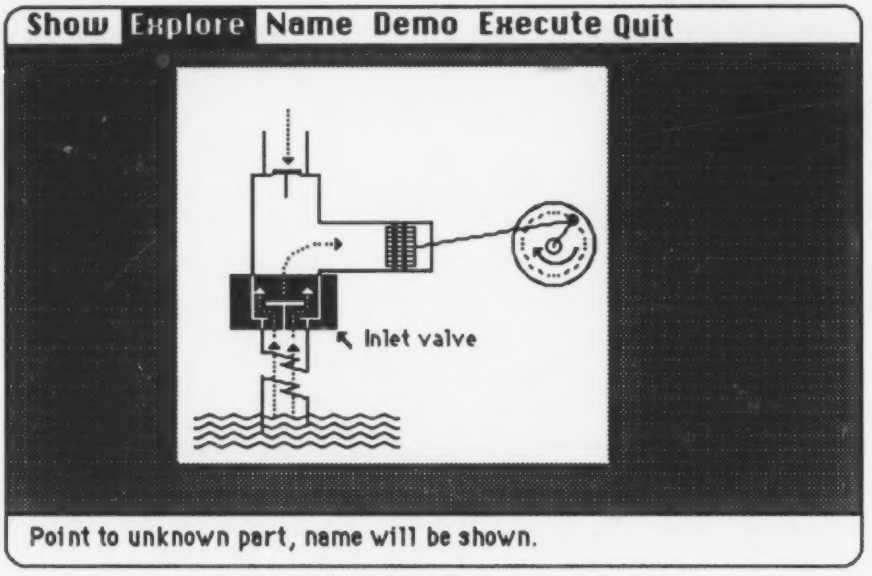


Figure 3. 30 Explore Parts Transaction

NAME PARTS

Name parts is the practice transaction for naming the parts of the device. In the display shown a part is highlighted and the student is asked to type in the name of the part. An alternative technique is to give the name or function of the part and ask the student to locate the part on the diagram. Other transaction variables include whether the naming is timed or under learner control, the criterion of how many correct or how many times each must be correct. The setting of these detailed display parameters is beyond the current capabilities of the prototype ID Expert.

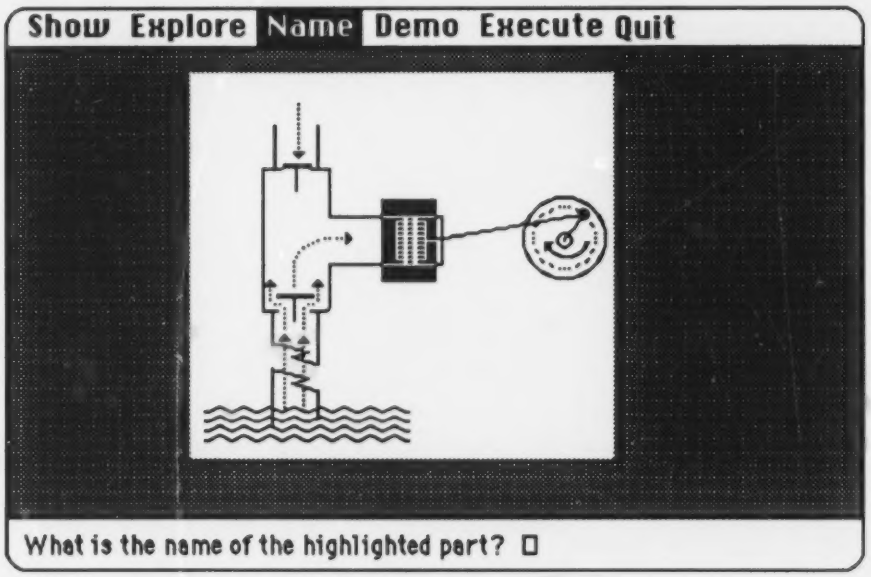


Figure 3.31 Name Parts Transaction

DEMO OPERATION

The Demo Operation transaction is the primary presentation for the procedure or subprocedure being taught. The steps of the procedure are identified and then the step is demonstrated either via still computer graphics, animation or video. Parameters include timed vs student paced demonstration. Steps could be indicated in written form as shown or provided via speech synthesis with voice over the demonstration. The decisions on such parameters of the presentation are beyond the scope of the prototype ID Expert.

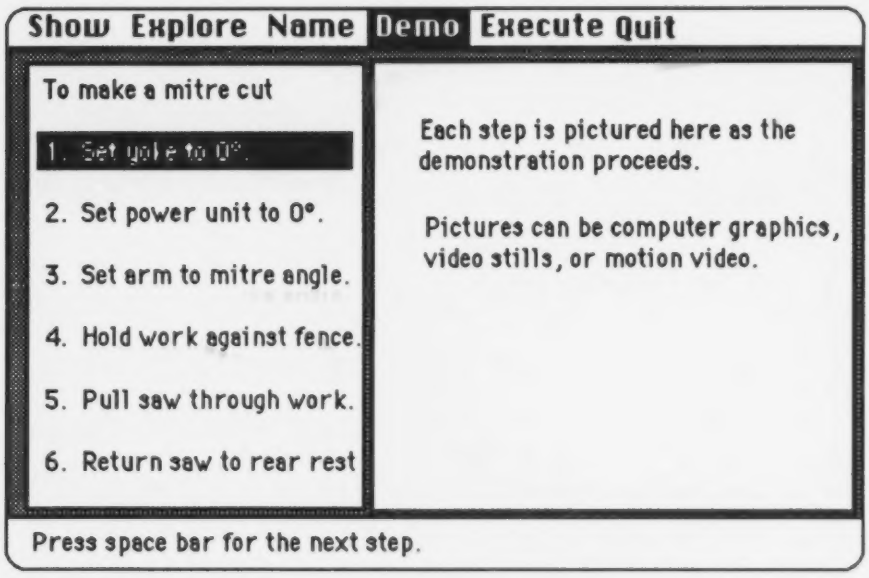

Show Explore Name Demo Execute Quit
To make a mitre cut
1. Set guide to 0°.
2. Set power unit to 0°.
3. Set arm to mitre angle.
4. Hold work against fence.
5. Pull saw through work.
6. Return saw to rear rest
Each step is pictured here as the demonstration proceeds.
Pictures can be computer graphics, video stills, or motion video.
Press space bar for the next step.

Figure 3.32 Demonstration Transaction

EXECUTE OPERATION

Execute the operation is the primary practice transaction which requires the student to either do the operation (procedure) or simulate the execution of the procedure. The technique illustrated by the display is a error detection type of execution where the student observes the procedure being executed and then stops the demonstration when an error or incorrect step occurs. The student then identifies the error or indicates how the procedure should have been executed.

Alternative execution transactions would allow the student to simulate the procedure by identifying the part of the device under consideration and then doing something to indicate the action to be taken.

Parameters for execution transactions include the presentation of a check list or not, the timing of the procedure or student paced, the type of errors to be included, etc. The decisions about such parameters are beyond the scope of the prototype system.

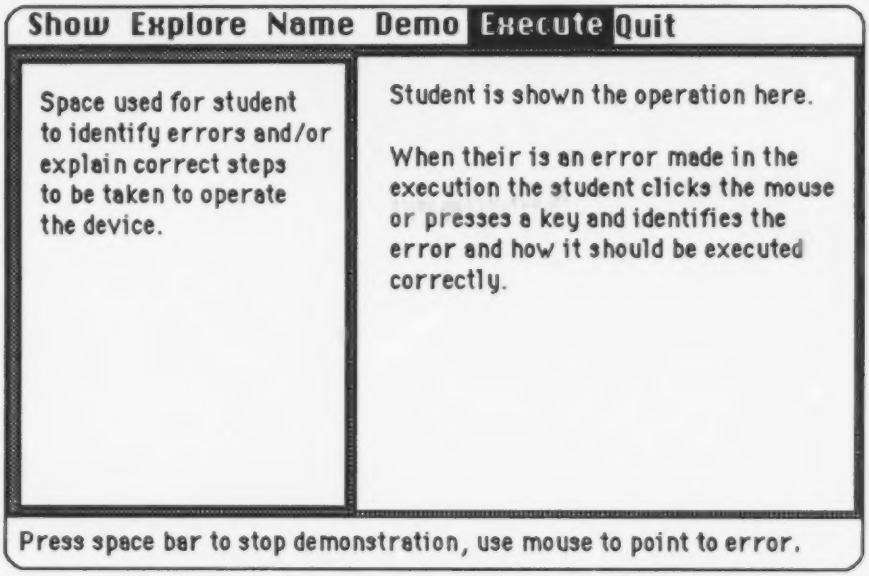

Show Explore Name Demo Execute Quit
Space used for student to identify errors and/or explain correct steps to be taken to operate the device.
Student is shown the operation here.
When their is an error made in the execution the student clicks the mouse or presses a key and identifies the error and how it should be executed correctly.
Press space bar to stop demonstration, use mouse to point to error.

Figure 3. 33 Execute Operation Transaction

RECOGNIZE STEPS

If the role of the student is a consumer or supervisor and the function of the module is merely familiarity then it may not be necessary for the student to practice execution of the operation but merely to be able to recognize the steps involved. The recognize steps transaction allows the system to assess the students recall or recognition of the steps involved without having to actually execute or evaluate the execution of these steps.

For some situations a Recall transaction may be more appropriate than a recognize transaction. Recall would would require the students to remember the steps rather than to merely order the steps from a list. The selection of recall or remember is beyond the scope of the ID prototype system.

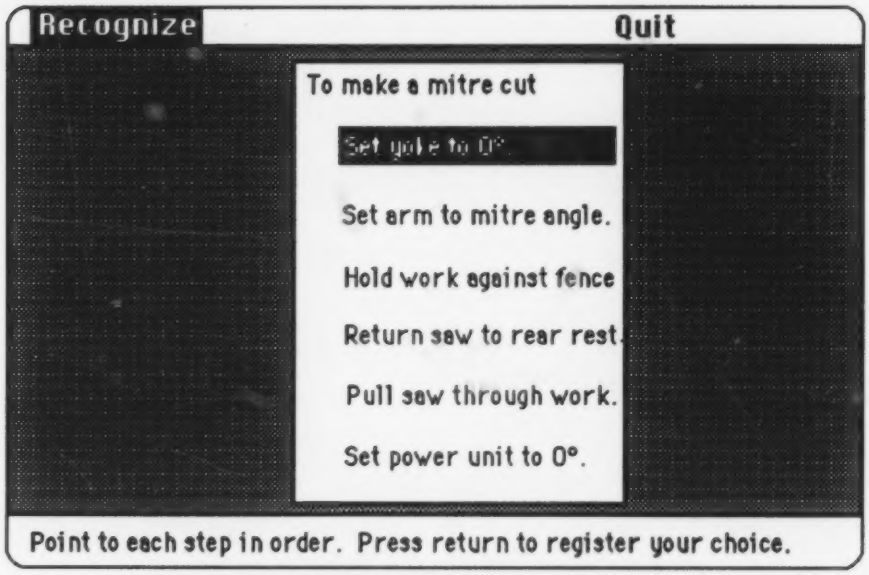

Recognize
Quit
To make a mitre cut
Set yoke to 0°
Set arm to mitre angle.
Hold work against fence
Return saw to rear rest.
Pull saw through work.
Set power unit to 0°.
Point to each step in order. Press return to register your choice.

Figure 3.34 Recognize Steps Transaction

3.3 DESCRIPTION OF KNOWLEDGE REPRESENTATION -RULES

The system described in this Design Document and Technical Report is a prototype system. To quote a recent article (Gehani, N.H. "An Electronic Form System -- An Experience in Prototyping." Software-Practice and Experience, vol 13, 479-486, 1983): "The design goals of a prototype are quite different from those of the final product. A prototype system is constructed to illustrate the feasibility of new ideas or design. . . . Shortcuts are taken to produce the prototype quickly at the expense of efficiency, robustness, generality and a good user interface. . . . Consequently, a prototype system should be considered to be a throw away system and the final system built from scratch."

Because this is a prototype there are a number of inconsistencies. These include inconsistencies in concept as represented in previous sections of this report but even more striking are the inconsistencies in the construction of the knowledge base.

We have explored a number of techniques for constructing a knowledge base including but not limited to the following:

Decision tree rules. These are straight forward rules that can be represented by a decision tree. Many of the rules in the GOAL Expert section and the PATHS Consultation section of the knowledge base can be represented by decision trees.

A variation on a decision tree is a set of attributes which all contribute to only a few outcomes but which can still be represented as a decision tree. The difference is that careful construction of AND/OR rules enable one to represent these many attributes with only a few rules. An example is the nested MOTIVATION Expert.

Accumulation of evidence reasoning using certainty factors. In this case a number of attributes all contribute to a decision but many of the factors are based on a partial contribution to the decision based on certainty factors. In this situation a number of rules fire each adding or subtracting to the final certainty of a particular decision. The final decision is made by setting some cut off value and recommending any conclusions which exceed this value. This technique is used in the KINDS Consultation. The rules are represented in this report by certainty factor tables rather than by decision trees.

Using the control blocks of the S.1 shell enables us to mix procedural and declarative programing techniques. One application of controlled reasoning is allowing the user/designer to confirm a certain recommendation before continuing with the reasoning process. If the user/designer does not concur with the recommendation they are allowed to regress and supply different values for a portion of the attributes and to receive a modified recommendation. This technique was used in the KINDS Consultation to confirm module functions. The selection of the user controls the remainder of the reasoning process.

We also explored the nesting of mini experts within the main stream of the reasoning process. This technique is best illustrated by the MOTIVATION Expert which is nested in the dialog for gathering audience attributes. If the user/designer answers unknown for the question on motivation the system jumps to the MOTIVATION Expert and gathers information necessary to make a decision about motivation. To a lesser extent this same technique is also used for making decisions about focus and relationship while instantiating the KINDS taxonomy.

3.3.1 GOAL/CONTENT STRUCTURE DECISION RULES

In the prototype system values on three attributes lead the user/designer to a set of from one to four goals. The goals and attributes have been previously listed in section 3.2 of this report. GOAL = F(Orientation, Object and Generality). The rules for recommending a goal are represented in Figures 3.35 - 3.37. These figures are decision tree representations of the rules leading to various goals. In the figures the first set of nodes represent values on the attribute orientation (What, How, Works), the second set of nodes represent values on the attribute object (symbols, device, events, persons) and the third set of nodes represent values on the attribute Generality (general, specific). The forth set of nodes are the various goals.

Content structure is a direct function of the type of goal. The what-device-general path leads to a kinds taxonomy (figure 3.35). The instantiation of this content structure and the module, sequence and transaction decisions that follow are described for the KINDS CONSULTATION in section 3.3.2.

The how-device path (figure 3.36) leads to various complex content structures for the operate/assemble goals. For this path the fifth set of nodes represent values on the attribute Activity (same, different) and the sixth set of nodes represent values on the attribute device operation (same, different). The seventh set of nodes represents the various content structures for an operate/assemble a device goal.

The decision trees in figures 3.35 - 3.37 indicate the many goals for which we have not yet identified appropriate content structures. Later versions of the system will be expanded to handle all of these branches.

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Figure 3.35 Goal/Content Structure decision tree for "what" orientation

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Figure 3.36 Goal/Content Structure decision tree for "how" orientation"

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Figure 3.37 Goal/Content Structure decision tree for "works" orientation.

3.3.2 MOTIVATION EXPERT (see section 3.2.1.1)

The motivation expert is nested within the audience attribute information gathering section of the ID Expert. If the user/designer indicates that the value for motivation is unknown then the motivation expert is invoked. Figures 3.38 and 3.39 indicate the decision structure for the motivation expert. The attributes involved are volunteer (yes, no), promotion (yes, no), raise (yes, no), job change (yes, no) and job change requested (yes, ?, no). Since there are only three possible outcomes for motivation this entire decision tree is represented in the system by only a few AND/OR rules.

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Figure 3.38 Motivation Expert Decision Tree part 1

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11/9/89

Figure 3.39 Motivation Expert Decision Tree part 2

3.3.2 KINDS CONSULTATION

3.3.2.1 Course Organization Rules

The first set of rules is applied to every coordinate set in the KINDS taxonomy and uses information about the concept relationship and focus of instruction to determine the type of module and which parts of the taxonomy are included in a particular module. These rules also determine the objective to be presented and also any messages concerning additional decisions the user/designer must make concerning the selection of modules. The rules are here represented in a matrix where concept relationship is on the left and focus is across the top. The entries in the cells are the conclusions concerning the type of module(See section 3.2.3.2), the objectives to be included and any qualifications represented by the messages which follow the table. There are actually a second set of rules generated by the user's reaction to the messages.

Table 3.1 Module Type

Module Type, Module Objective, Message = F(Concept Relationship, Focus)						
	Focus -->					
Relationship	**Discrim**	**Rank**	**Identify**	**General**	**Kinds**	
Independent NODE		COR-SET		NODE	COR-SUP	SUP-
Objective	DIS		ID	GEN	KND	
Message	DIS-IND	Don't ask?				
Coordinate	COR-SET		NODE	COR-SUP	COR-SUP	
Objective	DIS		ID	GEN/DIS	KND/DIS	
Message		Don't ask?	ID-COR	GEN-COR	KND-COR	
Order	COR-SET	COR-SET	NODE	COR-SUP	COR-SUP	
Objective	DIS/ORD	ORD	ID/ORD	DIS/COR/GEN	KND/DIS/ORD	
Message	DIS-ORD		ID-ORD	GEN-ORD	KND-ORD	
Overlap	COR-SET	COR-SET	NODE	COR-SUP	COR-SUP	
Objective	DIS/ORD	ORD	ID/ORD	ORD/GEN	KND/OVR	
Message	DIS-OVR		ID-OVR	GEN-OVR	KND-OVR	
Continuum		COR-SET		COR-SUP	COR-SUP	
Objective		ORD		GEN/OVR	KND/ORD	
Message	Don't ask?		Don't ask?	GEN-CON	KND-CON	

KEY to Table 3.1 Module Type:

Relationship	Abbreviation	Focus	Abbreviation
Independent	IND	Discriminate	DIS
Coordinate	COR	Rank	RNK
Order	ORD	Identify	ID
Overlap	OVR	Generalize	GEN
Continuum	CON	Kinds	KND

Module type	Abbreviation
Single-node	NODE
Coordinate	COR-SET
Coordinate-Superordinate	COR-SUP
Superordinate-Node	SUP-NODE

Messages associated with Table 3.1 Module Type:

Msg_Discriminate_independent

Since it is unlikely that students will confuse instances of [A1], [A2] and [An] then it is usually not necessary for students to learn to discriminate instances of [A1], [A2] and [An] from one another.

Would you like to change the focus? Y/N
» If Yes repeat focus dialog for this coordinate set.

Would you like to change the characterization of the categories? Y/N
» If Y repeat categories dialog for this coordinate set.

We will assume that for some reason you want the student to discriminate instances of [A1], [A2] and [An] from one another even though it is unlikely that students will confuse instances of [A1], [A2] and [An].

Msg_Discriminate_Order

Since [A1], [A2] and [An] are ordered with respect to each other do you want the student to order instances of [A1], [A2] and [An] as well as discriminating instances from one another? Y/N
» If Y Obj_Discriminate and Obj_Order

Would you like to change the focus? Y/N
» If Yes repeat focus dialog for this coordinate set.

Would you like to change the characterization of the categories? Y/N
» If Y repeat categories dialog for this coordinate set.

We will assume that you want the student to attempt to discriminate instances of [A1], [A2] and [An] from one another but to ignore the ordering.

Msg_Discriminate_Overlap

Since [A1], [A2] and [An] overlap it may be difficult for the student to discriminate border line cases. It may be better to ask the student to order instances of [A1], [A2] and [An] rather than to discriminate instances from one another.

Would you like to change the focus? Y/N
» If Yes repeat focus dialog for this coordinate set.

Would you like to change the characterization of the categories? Y/N
» If Y repeat categories dialog for this coordinate set.

We will assume that for some reason you want the student to attempt to discriminate instances of [A1], [A2] and [An] from one another in spite of the overlap.

Since [A1], [A2] and [An] overlap do you also want the student to order instances of [A1], [A2] and [An] along the dimension [C] from [Cleft] to [Cright]? Y/N
» If Y Obj_Discriminate and Obj_Order.
» If N Obj_Discriminate

Msg_Identify_Coordinate

Since [A1], [A2] and [An] are coordinate concepts where instances of [A1], [A2] and [An] are likely to be confused then it may be better to ask the student to discriminate instances of [A1], [A2] and [An] from one another rather than asking the student to identify instances of [A1], [A2] and [An] independently.

Would you like to change the focus? Y/N
» If Yes repeat focus dialog for this coordinate set.

Would you like to change the characterization of the categories? Y/N
» If Y repeat categories dialog for this coordinate set.

We will assume for some reason that you want the student to identify instances of each concept, [A1], [A2] and [An], rather than discriminating instances from one another.

Msg_Identify_Order

Since [A1], [A2] and [An] are ordered with respect to each other would you like the student to order instances of [A1], [A2] and [An] in addition to asking the student to identify instances of [A1], [A2] and [An]. Y/N
» If Y then Obj_Identify and Obj_Order

Would you like to change the focus? Y/N
» If Yes repeat focus dialog for this coordinate set.

Would you like to change the characterization of the categories? Y/N
» If Y repeat categories dialog for this coordinate set.

We will assume for some reason that you want the student to identify instances of each concept, [A1], [A2] and [An], rather than ordering instances.

Msg_Identify_Overlap

Since [A1], [A2] and [An] overlap would you like the student to order instances of [A1], [A2] and [An] in addition to asking the student to identify instances of [A1], [A2] and [An]. Y/N
» If Y then Obj_Identify and Obj_Order

Would you like to change the focus? Y/N
» If Yes repeat focus dialog for this coordinate set.

Would you like to change the characterization of the categories? Y/N
» If Y repeat categories dialog for this coordinate set.

We will assume for some reason that you want the student to identify instances of each concept, [A1], [A2] and [An], rather than ordering instances.

Msg_Generalize_Coordinate

Since [A1], [A2] and [An] are coordinate concepts where instances of [A1], [A2] and [An] are likely to be confused would you like the student to discriminate instances of [A1], [A2] and [An] from one another as will as asking the student to identify instances of [A1], [A2] and [An] as instances of [A]. Y/N
» If Y then Obj_Generalize and Obj_Discriminate

Would you like to change the focus? Y/N
» If Yes repeat focus dialog for this coordinate set.

Would you like to change the characterization of the categories? Y/N
» If Y repeat categories dialog for this coordinate set.

We will assume that you want the student to identify instances of [A1], [A2] and [An] as instances of [A] without also discriminating instances of [A1], [A2] and [An] from one another.

Msg_Generalize_Order

Since [A1], [A2] and [An] are ordered with respect to each other would you like the student to order instances of [A1], [A2] and [An] as will as asking the student to identify instances of [A1], [A2] and [An] as instances of [A]. Y/N
» If Y then Obj_Generalize and Obj_order.

Would you like to change the focus? Y/N
» If Yes repeat focus dialog for this coordinate set.

Would you like to change the characterization of the categories? Y/N
» If Y repeat categories dialog for this coordinate set.

We will assume that you want the student to identify instances of [A1], [A2] and [An] as instances of [A] without asking the student to order instances of [A1], [A2] and [An].

Msg_Generalize_Overlap

Since [A1], [A2] and [An] overlap would you like the student to order instances of [A1], [A2] and [An] in addition to asking the student to identify instances of [A1], [A2] and [An] as instances of [A]. Y/N
» If Y then Obj_Generalize and Obj_Order

Would you like to change the focus? Y/N
» If Yes repeat focus dialog for this coordinate set.

Would you like to change the characterization of the categories? Y/N
» If Y repeat categories dialog for this coordinate set.

We will assume for some reason that you want the student to identify instances of [A1], [A2] and [An] as instances of [A] without ordering instances of [A1], [A2] and [An].

Msg_Generalize_Continuum

Since instances of [A] are on a continuum would you like the student to order instances of [A] as well as asking the student to identify instances of [A]? Y/N
» If Y then Obj_Generalize and Obj_order.

Would you like to change the focus? Y/N
» If Yes repeat focus dialog for this coordinate set.

Would you like to change the characterization of the categories? Y/N
» If Y repeat categories dialog for this coordinate set.

We will assume that you want the student to identify instances of [A] without asking the student to order instances of [A].

Msg_Kinds of_Coordinate

Since [A1], [A2] and [An] are coordinate concepts where instances of [A1], [A2] and [An] are likely to be confused would you like the student to discriminate instances of [A1], [A2] and [An] from one another as will as asking the student to identify instances of [A] as instances of [A1], [A2] and [An]. Y/N
» If Y then Obj_Kinds of and Obj_Discriminate

Would you like to change the focus? Y/N
» If Yes repeat focus dialog for this coordinate set.

Would you like to change the characterization of the categories? Y/N
» If Y repeat categories dialog for this coordinate set.

We will assume that you want the student to identify instances of [A] as instances of [A1], [A2] and [An] as instances of [A] without also discriminating instances of [A1], [A2] and [An] from one another.

Msg_Kinds of_Order

Since [A1], [A2] and [An] are ordered with respect to each other would you like the student to order instances of [A1], [A2] and [An] as will as asking the student to identify instances of [A] as instances of [A1], [A2] and [An]. Y/N
» If Y then Obj_Kinds of and Obj_order.

Would you like to change the focus? Y/N
» If Yes repeat focus dialog for this coordinate set.

Would you like to change the characterization of the categories? Y/N
» If Y repeat categories dialog for this coordinate set.

We will assume that you want the student to identify instances of [A] as instances of [A1], [A2] and [An] without asking the student to order instances of [A1], [A2] and [An].

Msg_Kinds of_Overlap

Since [A1], [A2] and [An] overlap would you like the student to order instances of [A1], [A2] and [An] in addition to asking the student to identify instances of [A] as instances of [A1], [A2] and [An]. Y/N
» If Y then Obj_Kinds of and Obj_Order

Would you like to change the focus? Y/N
» If Yes repeat focus dialog for this coordinate set.

Would you like to change the characterization of the categories? Y/N
» If Y repeat categories dialog for this coordinate set.

We will assume for some reason that you want the student to identify instances of [A] as instances of [A1], [A2] and [An] without ordering instances of [A1], [A2] and [An].

Msg_Kinds of_Continiuum

Since instances of [A] are on a continuum would you like the student to order instances of [A] as well as asking the student to identify instances of [A]? Y/N
» If Y then Obj_Kinds of and Obj_order.

Would you like to change the focus? Y/N
» If Yes repeat focus dialog for this coordinate set.

Would you like to change the characterization of the categories? Y/N
» If Y repeat categories dialog for this coordinate set.

We will assume that you want the student to identify instances of [A] without asking the student to order instances of [A].

3.3.2.2 Module Sequence Algorithm

The procedure for determining module sequence for Kind Content Structures is a procedural algorithm rather than a decision based on declarative programing. The following pseudo code program describes this procedure.

ID EXPERT Merrill & Li
11/9/89

******** Table 3.2 Sequence Pseudo Code Algorithm **********

```
Procedure Sequence (Head:          );
    Begin
        If children of head belong to same structure.module
            Then COE = Inst.Mod.
        Else
        If children belong to N different structure.modules
            Then list N parallel COE  where each = Inst.Mod.
        Else
        COE = Placeholder;

        For i = 1 to N do
        Begin
            Create  COE (i)= dummy for child.node (i);
            If child.node (i) belongs to structure. module = coord.super
                AND Focus = generalize
            Then place COE (i) = dummy before  COE (i) = Inst.Mod for
            child.node  (i)
            Else
                place COE (i)=dummy after COE (i)=Inst. Mod. for child.node (i);

            If child.node (i) = terminal.node
                Then eliminate corresponding COE (i) = dummy
            Else
                If all children.node of child.node (i) = terminal.node
                    AND all children.node of child.node (i) belong to same
                        structural.module then COE (i) = Inst.Mod
                Else
                    COE (i) = MAP;
        End;

    For i = 1 to N do
        Begin
        If C.O.E. (i) = MAP
        Then Sequence (C.O.E. (i));
        End;

    End;
```

****************** End Sequence Pseudo Code ******************

KEY to notation for pseudo code:

Structure.Module = modules determined by module type rules
COE = Course.Organization. Element which can assume 3 values
- Inst.Mod. = Instructional Module
- MAP = nested course organization
- Placeholder = dummy slot in course organization

Node = each concept in the taxonomy
Head = superordinate node in taxonomy
Child = subordinate node in taxonomy
Focus = generalize from module rules
Module = coordinate.superordinate from module types see module rules.

3.3.2.3 Module Function Rules

For each module identified by the algorithm described in section 3.3.2.2 the following rules are applied to recommend one or more functions for the module. The user/designer selects which of the recommended functions are intended for the module.

Table 3.3 Module Function

FUNCTIONS = F(MODULE_TYPE, FAMILIARITY)							
IF Module_Type =	THEN CATEGORY =						
	OVUE	NPRS	OPRS	EPRC	LPRC	RVUE	ASSM
A PreIntegrative	0.80	-1.00	-1.00	-1.00	-1.00	-1.00	0.80
B PostIntegrative	-1.00	-1.00	-1.00	-1.00	0.60	0.60	0.60
C instructional	-0.30	0.60	0.50	0.50	0.60	0.40	0.40
IF Familiarity =							
A high	-0.30	-0.30	0.50	-0.30	0.00	0.00	-0.30
B moderate	0.00	0.00	0.00	0.10	0.20	0.30	0.00
C low	0.40	0.50	-0.30	0.50	0.30	0.50	0.40

KEY: Table 3.3

Function	Abbreviation
Overview	OVUE
New Presentation	NPRS
Old Presentation (Remediation)	OPRS
Early Practice	EPRC
Late Practice	LPRC
Review	RVUE
Assessment	ASSM

CF also indicates importance of function for the sample. e.g. CF= .70 or above indicates that it should be included. CF= .30 or below indicates that it is unnecessary to include.

3.3.2.4 Transaction Type Rules

For each module identified by the algorithm described in section 3.3.2.2 the following rules are applied to recommend one or more types of transactions for the module. The user/designer selects which of the recommended transaction types are to be included in the instruction.

This section of the ID Expert uses the accumulation of evidence type of reasoning. Each of the rules (except those having a 1.0 or -1.0) are uncertain rules. This means that a firm recommendation cannot be made. As long as a rule has not reached the 1.0 or -1.0 level of certainty any other rules that conclude the same type of transaction will also fire. As each rule fires the cf for the conclusion is increased or increased

depending on the values associated with the conclusion for each succeeding rule. After all of the applicable rules have fired there is a rule for selecting all those conclusions which have a cf exceeding .40 and recommending them to the user/designer together with their certainty factors.

Table 3.4 Transaction Type

TRANSACTION TYPE = F(FUNCTION,RELATIONSHIPS, CHARACTERISTICS, STUDENTS, FOCUS)											
IF FUNCTION =	THEN TRANSACTION TYPE =										
	SYNT	SUM	EXPO	CNVT	CMCN	EDIT	INTR	SQRT	LABL	RANK	QUES
Overview	0.40	0.30	0.10	0.20	0.00	-1.00	-1.00	-1.00	-1.00	-1.00	0.10
Presentation new	-1.00	-1.00	-0.40	0.40	0.40	0.00	0.00	0.00	0.00	0.00	0.20
Remediation (old)	0.30	0.30	0.20	0.40	0.40	0.30	0.30	0.30	0.30	0.30	0.30
Practice (early)	-1.00	-1.00	-1.00	-1.00	0.00	0.40	0.40	0.40	0.40	0.40	0.30
Practice (late)	-1.00	-1.00	-1.00	-1.00	0.40	0.40	0.40	0.40	0.40	0.40	0.30
Review	0.40	0.40	0.40	0.40	0.10	0.00	0.00	0.00	0.00	0.00	0.10
Assess/diag	-1.00	-1.00	-1.00	-1.00	-1.00	0.40	0.40	0.40	0.40	0.40	0.30
IF CONCEPT RELATIONSHIPS =											
Independent	-1.00	0.10	0.00	0.00	-0.20	0.00	0.00	0.00	0.20	-1.00	0.20
Coordinate set	0.10	0.00	0.00	0.00	0.20	0.20	0.20	0.20	0.10	-1.00	0.20
Order	0.10	0.00	0.00	0.00	0.10	0.10	0.10	0.00	0.10	0.30	0.00
Overlap	0.10	0.00	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.30	0.00
Continuum	0.10	0.00	0.00	0.00	0.00	0.00	0.00	-1.00	-1.00	0.30	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IF CONCEPT CHARACTERISTICS =											
Embedded vs	0.00	0.00	0.00	0.00	0.10	0.30	0.30	-0.20	-0.20	-0.10	0.00
Isolated	0.00	0.00	0.00	0.00	0.00	-0.20	-0.20	0.30	0.30	0.10	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Concrete vs	-0.10	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Abstract	0.30	-0.10	0.00	0.20	0.10	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Few attributes vs	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Many attributes	0.20	-0.10	0.00	0.20	0.10	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Text vs	0.00	0.00	0.00	0.00	0.00	0.00	-1.00	0.00	0.00	0.00	0.00
Illustrative	0.00	0.00	0.00	0.00	0.00	-1.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

IF STUDENT CHARACTERISTICS =											
Motivation High	0.00	0.20	0.20	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00
Motivation Mod	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Motivation Low	0.20	0.00	0.00	0.20	-0.20	0.00	0.00	0.00	0.00	0.00	0.00
Motivation Unkn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Familiarity High	0.00	0.20	0.20	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00
Familiarity Mod	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00
Familiarity Low	0.20	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Familiarity Unkn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Loc of Cont Ext	0.20	0.00	0.00	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Loc of Cont Int	0.00	0.00	0.10	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00
Loc of Cont Unkn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IF FOCUS =											
Identify	0.00	0.10	0.00	0.00	-0.60	0.00	0.00	0.20	0.20	-0.20	0.00
Discriminate	0.10	0.00	0.00	0.10	0.20	0.20	0.20	0.20	0.00	-0.20	0.00
Rank/Order	0.00	0.10	0.00	0.20	0.10	0.00	0.00	-0.10	-0.10	0.30	0.00
Generalize	0.10	0.00	0.00	0.10	-0.30	-0.10	-0.10	-0.10	0.20	-0.10	0.00
Kinds of	0.10	0.00	0.00	0.10	-0.40	-0.10	-0.10	-0.10	0.20	-0.10	0.00
Place Holder	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

KEY to Table 3.4
(For detailed descriptions of transaction types see Section 3.2.3.4 of this report.)

Transaction Type	Abbreviation	Transaction Type	Abbreviation
Synthesis	SYNT	Interpret	INTR
Summary	SUM	Sort	SORT
Exposition	EXPO	Label	LABL
Conversational Tutorial	CNVT	Rank	RANK
Compare and Contrast	CMCN	Question	QUES
Edit	EDIT		

3.3.2.5 Transaction Characteristic Rules

After the user/designer has selected the transactions to be included for each module the system applies the following four sets of rules to recommend transaction characteristics to the user/designer. The appropriate value for each characteristic is recommended for each transaction.

3.3.2.5.1 Transaction Sequence Rules

Table 3.5 Transaction Sequence

SEQUENCE = F(FUNCTION, TYPE, RELATIONSHIP, CHARACTERISTICS, STUDENTS, FOCUS)			
IF TYPE =	THEN SEQUENCE =		
SIM	SEQ	DEC	
SYNT	0.00	0.00	
SUM	-0.10	0.20	
EXPO	0.00	0.00	
CNVT	0.00	0.00	
CMCN	0.40	-0.20	
EDIT	0.40	-0.20	
INTR	0.40	-0.20	
SORT	0.00	0.00	
LABL	0.00	0.00	
RANK	0.00	0.00	
QUES	0.00	0.00	
IF RELATIONSHIP =			
Independent	-0.10	0.20	
Coord Set	0.20	-0.10	
Order	0.00	0.00	
Overlap	0.00	0.00	
Continuum	0.00	0.00	
Unknown	0.00	0.00	
IF CHARACTERISTICS =			
Embedded vs	0.20	-0.10	
Isolated	0.00	0.20	
Unknown	0.00	0.00	
Concrete vs			0.00
Abstract			0.30
Unknown			
Few attributes	0.10	0.00	0.00
Many attrib	0.00	0.10	0.40
Unknown	0.00	0.00	

IF STUDENT CHARACTERISTICS =			
Mot high	0.00	0.00	0.00
Mot moderate	0.00	0.10	0.10
Mot Low	-0.10	0.20	0.20
Mot Unknown	0.00	0.00	0.00
Famil High	0.10	0.00	0.00
Famil Moderate	0.00	0.00	0.10
Famil Low	-0.10	0.10	0.20
Famil Unknown	0.00	0.00	
IF FOCUS =			
Identify	0.00	0.20	
Discriminate	0.10	0.00	
Rank/Order	0.10	0.00	
Generalize	-0.10	0.10	
Kinds of	-0.10	0.10	
Place Holder	-1.00	-1.00	
Unknown	0.00	0.00	
IF FUNCTION =			
Overview	0.00	0.00	
New Present	-0.10	0.40	
Old Present	0.40	-0.10	
Early Practice	0.00	0.40	
Late Practice	0.40	0.00	
Review	0.40	-0.20	
Assess/Diagnosis	0.40	-0.20	

KEY to Table 3.5
(See section 3.2.3.5 of this report for detailed explanation of Transaction Sequence.)

Sequence	Abbreviation
Simultaneous	SIM
Sequential	SEQ
Decision Tree	DEC

DEC means that the sequence follows the decision tree.
The DEC items should be "AND" rules if the cf for sequential is greater than the cf for simultaneous then look at cf for decision sequence to see if it is significant.

Transaction Type	Abbreviation	Transaction Type	Abbreviation
Synthesis	SYNT	Interpret	INTR
Summary	SUM	Sort	SORT
Exposition	EXPO	Label	LABL
Conversational Tutorial	CNVT	Rank	RANK
Compare and Contrast	CMCN	Question	QUES
Edit	EDIT		

3.3.2.5.2 Transaction Content Representation Rules

Table 3.6 Transaction Content Representation

CONTENT REPRESENTATION = F(TYPE, SEQUENCE, STUDENT FAMILIARITY)									
THEN CONTENT REPRESENTATION =									
IF TYPE =	TAX	DEF	ALDF	ATDF	DECS	EGS	ATIS	CNTX	
SYNT	YES	YES		OPT		YES	OPT		
SUM		YES		OPT		OPT			
EXPO		YES	OPT	OPT		YES	OPT		
CNVT		YES	OPT	OPT		YES	OPT	YES	
CMCN		YES				YES	OPT		
EDIT		OPT				YES	OPT	YES	
INTR		OPT				YES	OPT	YES	
SORT		OPT				YES	OPT		
LABL		OPT				YES	OPT		
RANK		OPT				YES	OPT		
QUES		OPT							
IF SEQUENCE =									
Simultaneous									
Sequential									
Decision Tree					YES				
Random									
IF STUDENT =									
Famil high		0.20	0.20	0.20		0.20	0.20	0.20	
Famil mod		0.50	0.50	0.50		0.50	0.50	0.50	
Famil low		0.70	0.70	0.70		0.70	0.70	0.70	
Famil unknown			0.00	0.00	0.00		0.00	0.00	0.00

NOTES:

YES = must be present cf=1.0
NO = must not be present cf = -1.0
OPT = If requested by the user. cf = 0
Familiarity may be determined on line for each student.

Message:

You should include options.
It may be unnecessary to include options.
You probably should include options.

KEY to Table 3.6
(See section 3.2.3.5 of this report for further explanation of content representation.)

Content Representation	Abbreviation
Taxonomy Diagram	TAX
Definitions	DEF
Alternative Definitions	ALDF
Attribute Definitions	ATDF
Decision Structure	DECS
Examples	EGS

ID EXPERT Merrill & Li
11/9/89

Attribute Isolation (help) ATIS
Context CNTX

Transaction Type	Abbreviation	Transaction Type	Abbreviation
Synthesis	SYNT	Interpret	INTR
Summary	SUM	Sort	SORT
Exposition	EXPO	Label	LABL
Conversational Tutorial	CNVT	Rank	RANK
Compare and Contrast	CMCN	Question	QUES
Edit	EDIT		

3.3.2.5.3 Transaction Presentation Rules

Table 3.7 Transaction Presentation

PRESENTATION = F(TYPE, STUDENTS)			
	THEN PRESENTATION MODE =		
IF TYPE =	EXPO	INQ	MIX
SYNT	0.00	0.00	
SUM	0.00	0.00	
EXPO	1.00	-1.00	
CNVT	-1.00	-1.00	1.00
CMCN	0.00	0.10	
EDIT	0.00	1.00	
INTR	0.00	1.00	
SORT	0.00	1.00	
LABL	0.00	1.00	
RANK	0.00	1.00	
QUES	0.00	1.00	
IF STUDENT CHARACTERISTICS =			
Mot high	0.00	0.40	
Mot moderate	0.00	0.00	
Mot Low	0.40	0.00	
Mot Unknown	0.00	0.00	
Famil High	0.00	0.30	
Famil Moderate	0.00	0.00	
Famil Low	0.30	0.00	
Famil Unknown	0.00	0.00	
External LOC	0.20	0.00	
Internal LOC	0.00	0.20	
Unknown LOC	0.00	0.00	

KEY to Table 3.7

(See section 3.2.3.5 of this report for more explanation of Transaction Presentation Mode.)

Presentation Mode	Abbreviation
Expository	EXPO
Inquisitory	INQ
Mixed	MIX

Student Characteristic	Abbreviation
Locus of Control	LOC

3.3.2.5.4 Transaction Control Rules

Table 3.8 Transaction Control

CONTROL = F(TYPE, STUDENTS)		
IF STUDENT CHARACTERISTICS =	THEN INFO CONTL =	
	LRN	SYS
Mot high	0.40	0.00
Mot moderate	0.20	0.00
Mot Low	0.00	0.40
Mot Unknown	0.00	0.00
Famil High	0.30	0.00
Famil Moderate	0.20	0.00
Famil Low	0.00	0.00
Famil Unknown	0.00	0.00
External LOC	0.00	0.20
Internal LOC	0.20	0.00
Unknown LOC	0.00	0.00

KEY Table 3.8

Control	Abbreviation
Learner Control	LRN
System Control	SYS

Student Characteristic	Abbreviation
Locus of Control	LOC

3.3.3 PATHS CONSULTATION

3.3.3.1 Course Organization Rules

Course organization for path algorithm is determined by a recursive analysis of the elaborated content structure. The course organization consists of a series of nested maps such as that shown in figure 3.33. The degree of nesting and the number of maps is determined by the following algorithm and depends on the extent of the elaboration of the content structure.

In the simplest case (a series of 5 or 6 steps with no substeps) there is only a single module and the menus and integrative modules become unnecessary. In the more complex cases the boxes from menu i may be maps which themselves are represented by the course organization shown in the figure.

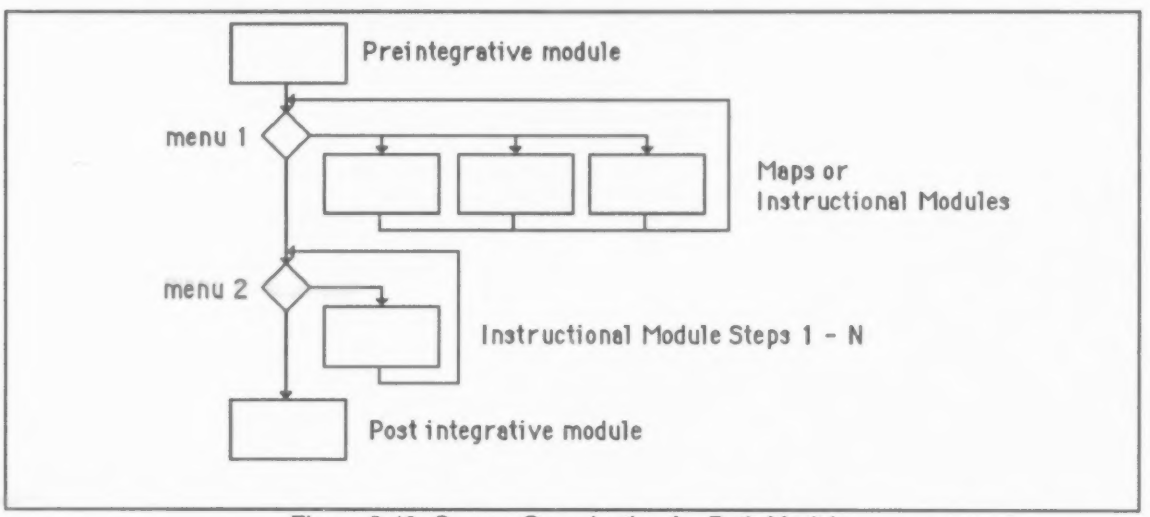

Figure 3.40 Course Organization for Path Module

The following pseudo code algorithm indicates the recursive analysis necessary to determine course structure for a path algorithm.

********** Table 3.9 Path Sequence Algorithm **********

REPEAT
Consider the procedure or Step (i)
If there are substeps then specify pre post integrative modules
Else specify an instructional module teaching steps 1 - n.

If step (i) has substeps and substeps have substeps then Map (i)
If step has substeps and substeps have no substeps then specify an instructional module teaching steps (ij) - (in).
If step has no substeps then omit from menu (i).

UNTIL no more steps.

********** End Path Sequence Algorithm **********

3.3.3.2 Strategy/Transaction Rules

The rules for recommending transaction strategies for a path:parts content structure are represented by the decision tree in Figure 3.33. In the figure the first node is the content structure path:parts (see figure 3.31), the second set of nodes represent values on the attribute role (consumer, supervisor, technician, problem solver - see section 3.2.1.1), the third set of nodes represent values on the attribute motivation (high, moderate, low - see section 3.2.1.1) and the fourth set of nodes represent values on the attribute familiarity (high, moderate, low - see section 3.2.1.1). The fifth set of nodes are the various strategies which each involve a number of different transactions (see section 3.2.4.3).

Insert figure showing path:parts strategy decision tree here

Figure 3.41 Decision Rules for Strategy/Transaction for Path:parts Content Structure.

3.4 USER INTERFACE -- CONSULTATION PROCESS

Because of the S.1 implementation of the current prototype the interaction with the system is very linear as reflected in the following consultations with the system. Future implementations of the system will provide a more interactive graphic interface with the user. The prototype concentrates on making reasonable decisions. The report of these decisions is textual. We have used graphic representations to describe the various attributes in this report and such graphic representations will be incorporated into future versions of the system.

The following are edited typescripts of actual interactions with the system. The order of some queries have been changed for clarity. The typescripts have been divided into sections which correspond to the Top level view of the system (section 3.1). These titles (shown in bold) do not appear in the actual typescript. Various attributes and the consultation reports have been cross referenced to correspond with various sections of this design document and technical report. User/designer input is shown by >. Comments which are not part of the typescript are shown in italics inside curly brackets { *comment here* }.

3.4.1 KINDS CONSULTATION

QUERY: Title

1: What is the title of the course?
1> PUMPS

QUERY: Audience Attributes (see section 3.2.1.1)

2: What is the locus of control of this group of students?
Type HELP for more information.
{*Many items are accompanied by more detailed information . Typing HELP displays this information. HELP is illustrated here but omitted from the remainder of the typescript for clarity.* }
2> HELP
Locus of Control is a variable which refers to the amount of control a student feels that they have in a situation. When students feel that they are in control they are willing to make decisions and to direct their own activities. When a student feels that others are in control they are more willing to let others direct them and make decisions for them. If you have data on the general orientation of the students either from formal tests of locus of control or from observing the students this information is helpful in making instructional decisions. If the students are managers, supervisors or other leaders their orientation is likely to be INTERNAL. If the students are not in a leadership position then their orientation is often EXTERNAL.

EXTERNAL locus of control means that the students generally feel that others are in control.

INTERNAL locus of control means that the students generally feel that they are in control.
2> UNKNOWN
{ *It is legal to answer any question with UNKNOWN if the user/designer does not have the information requested.* }

3: What is the average motivation for this group of students?
Type HELP for more information.
3> UNKNOWN
{ *Motivation contains a nested expert. The user could have typed HIGH, MODERATE or LOW and continued with the consultation. By typing UNKNOWN the nested motivation expert is called and more detailed questions enable the system to recommend the level of motivation.* }

4: Why will the student take this instruction?
Volunteer - students will have chosen to take this instruction.
Required - students will be required to take this instruction.
4> REQUIRED

5: Will this instruction contribute to a job promotion for the student?
5> YES

6: Will this instruction enable or require a job change for the student?
6> YES

7: Did the student request the job change which requires this instruction?
7> YES

8: Did the student request the job change which requires this instruction?
8> REQUESTED

INTERMEDIATE RESULT:
It has been determined that the student's motivation is high.

9: Will the student use the acquired skill primarily as:
CONSUMER - who needs general information.
SUPERVISOR - who directs the technical work of others.
TECHNICIAN - who executes skills to perform a service, produce a product or make repairs.
PROBLEM SOLVER - who understands how a device or process works in order to predict outcomes, derive new rules or procedures or design new products or communications.
9> TECHNICIAN

QUERY: Goal Attributes (see section 3.2.1.2)

10: Which of the following best describes what the student will learn?

WHAT.IS - What it is?

HOW.TO - How to do it?

WORKS - How does it work?
10> WHAT.IS

11: The student will be expected to demonstrate the acquired skill with:

SYMBOLS - including language, numbers or other symbols.

DEVICES - including devices or equipment.

EVENTS - including processes or procedures.

PERSONS - including personal characteristics or rules.

11> DEVICES

12: Will the student be expected to demonstrate the acquired skill with:

SPECIFIC - a specific object or set of objects which is the same from one occasion to the next?

GENERAL - sets of different objects which differ from one occasion to the next?

12> GENERAL

13: How familiar are the students with the content of the instruction (HIGH, MODERATE, LOW)?

13> LOW

14: What is the required level of mastery (HIGH, MODERATE, LOW)?

14> HIGH

RECOMMEND/QUERY: Goal (see section 3.2.1.3)

15: Which is an appropriate orienting goal for your instruction?

DISCRIMINATE - The student will be able to discriminate two or more different kinds of objects, devices or equipment.

SORT - The student will be able to sort objects, devices or equipment into categories.

GENERALIZE - The student will be able to identify different objects, devices or equipment as instances of a more general category.

ORDER - The student will be able to order a series of objects, devices or equipment relative to some dimension.

15> DISCRIMINATE

RECOMMEND: Content Structure (see section 3.2.2)

INTERMEDIATE RESULT:
A KINDS TAXONOMY Content Structure is recommended.

INSTANTIATE/ELABORATE: Kinds Content Structure (see section 3.2.3.1)

Now, we are building the kinds taxonomy from the top of the tree:

16: What is the top node concept?
16> Pumps

17: Do you wish to expand on pumps?
17> YES

18: What is the relationship between the categories in the coordinate set for pumps (INDEPENDENT, COORDINATE, ORDERED, OVERLAP, CONTINUUM)?
{ *If the user answers UNKNOWN here a more detailed set of questions are asked to assist in the determination of the relationship between the members of the coordinate set.* }
18> COORDINATE

19: List the kinds of Pumps in this coordinate set.
19> piston, centrifugal, jet

20: What is the primary focus of the instruction (IDENTIFY, DISCRIMINATE, RANK, GENERALIZE, KINDS.OF, PLACE.HOLDER)?
Type HELP for more information.
21> DISCRIMINATE
{ *While not illustrated by this typescript it is possible that there is an inconsistency between the concept relationship and the focus. If so one of the messages (see section 3.3.2.1) identifying this potential conflict and the alternative courses of action available to the user is presented. The user is allowed to accept the information already provided or to change either the focus or the relationship.* }

QUERY: Content Characteristics (see section 3.2.3.1)

22: Are the concepts in the coordinate set EMBEDDED or ISOLATED?
Type HELP for more information.
22> ISOLATED

23: Are the concepts in the coordinate set ABSTRACT or CONCRETE?
Type HELP for more information.
23> CONCRETE

24: Are the various concepts in the coordinate set defined by MANY or FEW attributes?
Type HELP for more information.
24> FEW

25: Are the concepts best represented by a DOCUMENT or by an ILLUSTRATION?
Type HELP for more information
25> ILLUSTRATION

26: Does the task require integrated performance (type YES) or are the skills relatively independent of one another (type NO)?
Type HELP for more information.
26> NO

{ *At this point in the dialog each of the coordinate concepts are taken in turn and the queries for instantiation and content characteristics are repeated until the user/designer indicates that there are no further elaborations.* }

27: Do you wish to expand on piston pumps?
27> YES

28: What is the relationship between the concepts in the coordinate set for piston pumps (INDEPENDENT, COORDINATE, ORDERED, OVERLAP, CONTINUUM)?
28> INDEPENDENT

{ *ETC. for queries 29 through 44 in the current typescript.* }

INTERMEDIATE RESULT
The KINDS content structure for Pumps is as follows:

Pumps
- Piston
  - Piston1
  - Vane
  - Lift
  - Diaphragm
- Centrifugal
- Jet

RECOMMEND: Course Organization (see section 3.2.3.2)

INTERMEDIATE RESULT
The following modules are recommended to teach pumps.

An integrative module for Pumps.

A coordinate set module for Piston, Centrifugal, Jet.
OBJECTIVE: The student will be able to discriminate instances of Piston, Centrifugal and Jet Pumps from one another.

A coordinate set module for Piston1, Vane, Lift and Diaphragm Piston Pumps.
OBJECTIVE: The student will be able to discriminate instances of Piston1, Vane, Lift and Diaphragm Piston Pumps from one another.

The following course organization is recommended.

Map #1

A preintegrative module for Pumps

A menu for the following module(s)
1. Piston, Centrifugal, Jet Pumps

A menu for the following module(s)
2. Piston1 Piston Pumps
3. Vane Piston Pumps
4. Lift Piston Pumps
5. Diaphragm Piston Pumps

A postintegrative module for Pumps

{ *A more complex course organization would have maps within menus and a nested content structure for each of these maps.* }

RECOMMEND: Module Functions (see section 3.2.3.3)

INTERMEDIATE RESULT
Recommended function(s) for preintegrative module Pumps.

A(n) overview function is strongly suggested (cf = .8).

45: What is/are the function(s) of this module?
45> OVERVIEW

{ *In many cases there may be several possible functions for a module in which case the user could select one or several functions for the module.* }

Recommended function(s) for postintegrative module Pumps.

A(n) assessment.diagnosis function is strongly suggested (cf = .8).
A(n) review is weakly suggested (cf = .3).

46: What is/are the function(s) of this module?
46> ASSESSMENT.DIAGNOSIS

Recommended functions(s) for instructional module Piston, Centrifugal, Jet Pumps.

A(n) new presentation function is strongly suggested (cf = .8).
A(n) early practice function is suggested (cf = .75).
A(n) late practice function is suggested (cf = .72).
A(n) assessment.diagnosis function is suggested (cf = .64).

47: What is/are the function(s) of this module?
47> NEW.PRESENTATION, EARLY.PRACTICE, LATE.PRACTICE

{ *This dialog continues for each of the modules identified for the course structure until all the functions have been recommended and accepted by the user/designer.* }

RECOMMEND: Transaction Types and Characteristics
(see section 3.2.3.4 and 3.2.3.5)

INTERMEDIATE RESULT
Recommended transaction type(s) for preintegrative module Pumps overview function.

A(n) summary transaction is suggested (cf = .48).
A(n) synthesis transaction is suggested (cf = .44).

49: Which transaction(s) would you prefer?
49> SYNTHESIS

Recommended transaction characteristics for a(n) synthesis transaction.

Presentation sequence should be sequential.
Presentation mode should be inquisitory.
Transaction control should be learner control.
Required content representation(s) should include:
taxonomy
definition
examples
Optional content representations(s) should include:
attribute.definition
attribute.isolation

Recommended transaction type(s) for postintegrative module Pumps assessment/diagnosis function.

Since the content is not integrated there is no need to integrate the assessment. Combining assessment from each module within the course organization map makes up the heterogeneous test for the postintegrative module.

Recommended transaction type(s) assessment function for the instructional module Piston, Centrifugal, Jet Pumps.

A(n) sort transaction is suggested (cf = .73).
A(n) label transaction is suggested (cf = .62).
A(n) interpret transaction is suggested (cf = .52).

50: Which transaction(s) would you prefer?
50> SORT

Recommended transaction characteristics for a(n) sort transaction.

Presentation sequence should be sequential.
Presentation mode should be inquisitory.
Transaction control should be learner control.
Required content representation(s) should include:
examples
Optional content representations(s) should include:

definition
attribute.isolation

{ *The consultation continues to make recommendations for each function of each module. The user/designer confirms the recommendations by selecting transactions from the options presented until all of the modules, functions and transactions have been specified.* }

DISPLAY: ID Specification for course

{ *The consultation concludes with a summary report which provides the instructional design specification for the course under consideration.* }

CONSULTATION REPORT
Course Title: Pumps

Audience Characteristics:
Role: Technician
Motivation: High
Familiarity: Low
Locus of Control: Unknown

Content Structure: KINDS TAXONOMY

Pumps
Piston
Piston1
Vane
Lift
Diaphragm
Centrifugal
Jet

Recommended Course Organization:

Map #1

A preintegrative module for Pumps

A menu for the following module(s)
1. Piston, Centrifugal, Jet Pumps

A menu for the following module(s)
2. Piston1 Piston Pumps
3. Vane Piston Pumps
4. Lift Piston Pumps
5. Diaphragm Piston Pumps

A postintegrative module for Pumps

Recommended Modules:

Module 1:
Type: Instructional
Content: Piston, Centrifugal, Jet Pumps
Objective: The student will be able to discriminate instances of Piston, Centrifugal, Jet Pumps from one another.

Function: assessment.diagnosis
Transaction: sort
Sequence: sequential
Presentation Mode: inquisitory
Control Mode: learner control
Required Content Representation: examples
Optional Content Representation: definition, attribute isolation

Function: new.presentation
Transaction: compare.contrast
Sequence: sequential
Presentation Mode: inquisitory
Control Mode: learner control
Required Content Representation: definitions, examples
Optional Content Representation: attribute isolation

Function: early.practice
Transaction: sort
Sequence: simultaneous
Presentation Mode: inquisitory
Control Mode: learner control
Required Content Representation: examples
Optional Content Representation: definition, attribute isolation

Function: late.practice
Transaction: compare.contrast
Sequence: sequential
Presentation Mode: inquisitory
Control Mode: learner control
Required Content Representation: definitions, examples
Optional Content Representation: attribute isolation

Module # 2

{ *The report continues until the instructional design specifications for each module are complete.* }

3.4.2 PATH CONSULTATION

QUERY: Title

1: What is the title of the course?
1> Speadsheet Budget

QUERY: Audience Attributes (see section 3.2.1.1)

2: What is the locus of control of this group of students?
Type HELP for more information.
2> UNKNOWN

3: What is the average motivation for this group of students?
Type HELP for more information.
3> MODERATE

4: Will the student use the acquired skill primarily as:
CONSUMER - who needs general information.
SUPERVISOR - who directs the technical work of others.
TECHNICIAN - who executes skills to perform a service, produce a product or make repairs.
PROBLEM SOLVER - who understands how a device or process works in order to predict outcomes, derive new rules or procedures or design new products or communications.
4> TECHNICIAN

QUERY: Goal Attributes (see section 3.2.1.2)

5: Often the learning appropriate for a technician is characterized by How to do it? Does this characterize what you want your students to learn?
5> YES
{ *The system anticipates that a technician is probably a how orientation. If the user/designer typed NO here they would be asked to specify the orientation.* }

6: The student will be expected to demonstrate the acquired skill with:

SYMBOLS - including language, numbers or other symbols.

DEVICES - including devices or equipment.

EVENTS - including processes or procedures.

PERSONS - including personal characteristics or rules.
6> DEVICES

7: Will the student be expected to demonstrate the acquired skill with:

SPECIFIC - a specific object or set of objects which is the same from one occasion to the next?

GENERAL - sets of different objects which differ from one occasion to the next?
7> SPECIFIC

8: How familiar are the students with the content of the instruction (HIGH, MODERATE, LOW)?
8> HIGH

RECOMMEND/QUERY: Goal (see section 3.2.1.3)

15: Which is an appropriate orienting goal for your instruction?

OPERATE - The student will be able to operate a device or piece of equipment.

ASSEMBLE - The student will be able to assemble or disassemble a device or piece of equipment.

DIAGNOSIS - The student will be able to diagnosis and repair malfunctions in a device or piece of equipment.

15> OPERATE

QUERY: Goal Clarification

16: Will the student be expected to execute

SAME - the same steps or actions from one occasion to the next?

DIFFERENT - different steps or actions from one occasion to the next depending on the conditions of the device or the actions to be accomplished?

16> SAME

RECOMMEND: Content Structure (see section 3.2.2)

INTERMEDIATE RESULT:
A PATH: PARTS Content Structure is recommended.

INSTANTIATE/ELABORATE: Paths Content Structure

17: What is the name of the procedure you wish to analyze?
17> Build Spreadsheet Budget

18: How many major steps are needed for performing this activity?
18> 4

Please arrange the steps in the optimal order and input the requested information for each step.
Type HELP for a definition of optimal order.

Define step 1.
19: What is the name of this step?
19> Setup budget template

Define step 2.
20: What is the name of this step?
20> Enter data

Define step 3.
21: What is the name of this step?
21> Adjust budget

Define step 4.

22: What is the name of this step?
22> Print budget

Elaboration of Content Structure.
23: Assume that all the necessary facts and concepts are known, is the step Setup budget template at the entry level of the lowest ability student?
23> NO

Elaboration of step Setup budget template.
24: How many steps are needed for performing this activity?
24> 3

Please arrange the steps in the optimal order and input the requested information for each step.
Type HELP for a definition of optimal order.

{ *This input algorithm iterates until all steps have elaborated and the user/designer indicates that no further elaboration of the procedure is necessary.* }

INTERMEDIATE RESULT
The operation for Build Spreadsheet Budget is represented by the following steps and substeps:

Build Spreadsheet Budget
- Setup budget template
  - Open spreadsheet
  - Define titles
    - Enter Personnel
    - Enter ODC items
    - Enter Overhead
  - Define formulas
    - Total =
    - Overhead =
- Enter data
- Adjust budget
- Print budget

{ *The procedure illustrated is not complete but shows the nesting of substeps within steps down several levels.* }

RECOMMEND: Course Organization

INTERMEDIATE RESULT
The following modules are recommended to teach the operation Build spreadsheet budget.

A(n) integrative module for the operation Build spreadsheet budget.
A(n) integrative module for the operation Setup budget template.
A(n) instructional module for the operation Build spreadsheet budget with the following steps: Setup budget template, Enter data, Adjust budget, Print budget.

A(n) instructional module for the operation Setup budget template with the following steps: Open spreadsheet, Define titles, Define formulas.

A(n) instructional module for the operation Define titles with the following steps: Enter personnel, Enter ODC items, Enter Overhead.

A(n) instructional module for the operation Define formulas with the following steps: Total =, Overhead =.

The following course organization is recommended:

Map #1
Preintegrative module for operation Build Spreadsheet Budget.

A menu for the following modules:
Map #2 for the operation Setup budget template

A menu for the following modules:
Module #2 for the operation Build Spreadsheet Budget

Postintegtrative module for operation Build Spreadsheet Budget.

Map #2
Preintegrative module for operation Setup budget template

A menu for the following modules:
Module # 5 for the operation Define Titles
Module # 6 for the operation Define Formulas

A menu for the following modules:
Module # 7 for the operation Setup budget template

Postintegrative module for operation Setup budget template

RECOMMEND: Strategy and Transactions

INTERMEDIATE RESULT
For each of the instructional transactions in the recommended course organization the following strategy and transactions are recommended:

REM:SLCBI - Remedial Structured Learner Control Basic Instruction

This strategy requires the following transactions:
Overview Demo
Show Parts
Explore Parts
Name Parts
Demo Operation
Execute Operation

DISPLAY: ID Specification for course

{ The consultation concludes with a summary report which provides the instructional design specification for the course under consideration. }

CONSULTATION REPORT
Course Title: Build Spreadsheet Budget

Audience Characteristics:
Role: Technician
Motivation: Moderate
Familiarity: High
Locus of Control: Unknown

Content Structure: PATH:PARTS ALGORITHM

Build Spreadsheet Budget
Setup budget template
Open spreadsheet
Define titles
Enter Personnel
Enter ODC items
Enter Overhead
Define formulas
Total =
Overhead =
Enter data
Adjust budget
Print budget

Recommended Course Organization:

Map #1
Preintegrative module for operation Build Spreadsheet Budget.

A menu for the following modules:
Map #2 for the operation Setup budget template

A menu for the following modules:
Module #2 for the operation Build Spreadsheet Budget

Postintegtrative module for operation Build Spreadsheet Budget.

Map #2
Preintegrative module for operation Setup budget template

A menu for the following modules:
Module # 5 for the operation Define Titles
Module # 6 for the operation Define Formulas

A menu for the following modules:
Module # 7 for the operation Setup budget template

Postintegrative module for operation Setup budget template

Recommended Modules:

Module 1:
Type: Preintegrative
Content: Build Spreadsheet Budget
Strategy: overview
Transaction: overview demo

Module 2:
Type: Instructional
Content: Setup budget template
Objective: The student will be able to execute the operation Setup budget template.
Strategy: REM:SLCBI
Transactions:
Overview Demo
Show Parts
Explore Parts
Name Parts
Demo Operation
Execute Operation

{ *The recommendations for modules 2 through 7 are the same as for Module 2.*
}

Module 8:
Type: Postintegrative
Content: Build Spreadsheet Budget
Strategy: Assessment
Transactions:
Execute Operation

4.0 APPENDIX
S.1 KNOWLEDGE BASE FOR PROTOTYPE ID EXPERT